

TETRAHYDRO-NAPHTHALENE DERIVATIVES

DETAILED DESCRIPTION OF INVENTION

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TECHNICAL FIELD

The present invention relates to a tetrahydro-naphthalene derivative which is useful as an active ingredient of pharmaceutical preparations. The tetrahydro-naphthalene derivative of the present invention has vanilloid receptor (VR) antagonistic activity, and can be used for the prophylaxis and treatment of diseases associated with VR1 activity, in particular for the treatment of overactive bladder, urinary incontinence, chronic pain, neuropathic pain, postoperative pain, rheumatoid arthritic pain, neuralgia, neuropathies, algesia, nerve injury, ischaemia, neurodegeneration, stroke, urge urinary incontinence, and inflammatory disorders such as asthma and chronic obstructive pulmonary (or airways) disease (COPD).

BACKGROUND ART

Vanilloid compounds are characterized by the presence of vanillyl group or a functionally equivalent group. Examples of several vanilloid compounds or vanilloid receptor modulators are vanillin (4-hydroxy-3-methoxy-benzaldehyde), guaiacol (2-methoxy-phenol), zingerone (4-(4-hydroxy-3-methoxyphenyl)-2-butanone), eugenol (2-methoxy-4-(2-propenyl)-phenol), and capsaicin (8-methoxy-N-vanillyl-6-noneneamide).

Among others, capsaicin, the main pungent ingredient in "hot" chili peppers, is a specific neurotoxin that desensitizes C-fiber afferent neurons. Capsaicin interacts with vanilloid receptors (VR), which are predominantly expressed in cell bodies of dorsal root ganglia (DRG) or nerve endings of afferent sensory fibers including C-fiber nerve endings [Tominaga M, Caterina MJ, Malmberg AB, Rosen TA, Gilbert H, Skinner K, Raumann BE, Basbaum AI, Julius D: The cloned capsaicin receptor

integrates multiple pain-producing stimuli. Neuron. 21: 531-543, 1998]. The VR1 receptor was recently cloned [Caterina MJ, Schumacher MA, Tominaga M, Rosen TA, Levine JD, Julius D: Nature 389: 816-824, (1997)] and identified as a non-selective cation channel with six transmembrane domains that is structurally related to the TRP (transient receptor potential) channel family. Binding of capsaicin to VR1 allows sodium, calcium and possibly potassium ions to flow down their concentration gradients, causing initial depolarization and release of neurotransmitters from the nerve terminals. VR1 can therefore be viewed as a molecular integrator of chemical and physical stimuli that elicit neuronal signals in a pathological conditions or diseases.

There are abundant of direct or indirect evidence that shows the relation between VR1 activity and diseases such as pain, ischaemia, and inflammatory (e.g., WO 99/00115 and 00/50387). Further, it has been demonstrated that VR1 transduce reflex signals that are involved in the overactive bladder of patients who have damaged or abnormal spinal reflex pathways [De Groat WC: A neurologic basis for the overactive bladder. Urology 50 (6A Suppl): 36-52, 1997]. Desensitisation of the afferent nerves by depleting neurotransmitters using VR1 agonists such as capsaicin has been shown to give promising results in the treatment of bladder dysfunction associated with spinal cord injury and multiple sclerosis [(Maggi CA: Therapeutic potential of capsaicin-like molecules - Studies in animals and humans. Life Sciences 51: 1777-1781, 1992) and (DeRidder D; Chandiramani V; Dasgupta P; VanPoppel H; Baert L; Fowler CJ: Intravesical capsaicin as a treatment for refractory detrusor hyperreflexia: A dual center study with long-term followup. J. Urol. 158: 2087-2092, 1997)].

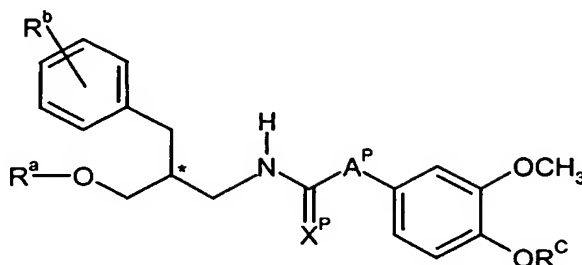
It is anticipated that antagonism of the VR1 receptor would lead to the blockage of neurotransmitter release, resulting in prophylaxis and treatment of the condition and diseases associated with VR1 activity.

It is therefore expected that antagonists of the VR1 receptor can be used for prophylaxis and treatment of the condition and diseases including chronic pain, neuropathic pain, postoperative pain, rheumatoid arthritic pain, neuralgia, neuropathies, algisia, nerve injury, ischaemia, neurodegeneration, stroke, incontinence, inflammatory disorders, urinary incontinence (UI) such as urge urinary incontinence (UUI), and/or overactive bladder.

UI is the involuntary loss of urine. UUI is one of the most common types of UI together with stress urinary incontinence (SUI) which is usually caused by a defect in the urethral closure mechanism. UUI is often associated with neurological disorders or diseases causing neuronal damages such as dementia, Parkinson's disease, multiple sclerosis, stroke and diabetes, although it also occurs in individuals with no such disorders. One of the usual causes of UUI is overactive bladder (OAB) which is a medical condition referring to the symptoms of frequency and urgency derived from abnormal contractions and instability of the detrusor muscle.

There are several medications for urinary incontinence on the market today mainly to help treating UUI. Therapy for OAB is focused on drugs that affect peripheral neural control mechanisms or those that act directly on bladder detrusor smooth muscle contraction, with a major emphasis on development of anticholinergic agents. These agents can inhibit the parasympathetic nerves which control bladder voiding or can exert a direct spasmolytic effect on the detrusor muscle of the bladder. This results in a decrease in intravesicular pressure, an increase in capacity and a reduction in the frequency of bladder contraction. Orally active anticholinergic drugs such as propantheline (ProBanthine), tolterodine tartrate (Detrol) and oxybutynin (Ditropan) are the most commonly prescribed drugs. However, their most serious drawbacks are unacceptable side effects such as dry mouth, abnormal visions, constipation, and central nervous system disturbances. These side effects lead to poor compliance. Dry mouth symptoms alone are responsible for a 70% non-compliance rate with oxybutynin. The inadequacies of present therapies highlight the need for novel, efficacious, safe, orally available drugs that have fewer side effects.

WO 00/50387 discloses the compounds having a vanilloid agonist activity represented by the general formula:



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wherein;

X^P is an oxygen or sulfur atom;

10 A^P is $-NHCH_2-$ or $-CH_2-$;

R^a is a substituted or unsubstituted C_{1-4} alkyl group, or $R^{a1}CO-$;

wherein

15

R^{a1} is an alkyl group having 1 to 18 carbon atoms, an alkenyl group having 2 to 18 carbon atoms, or substituted or unsubstituted aryl group having 6 to 10 carbon atoms;

20 R^b is a hydrogen atom, an alkyl group having 1 to 6 carbon atoms, an alkoxy group having 1 to 6 carbon atoms, a haloalkyl group having 1 to 6 carbon atoms or a halogen atom;

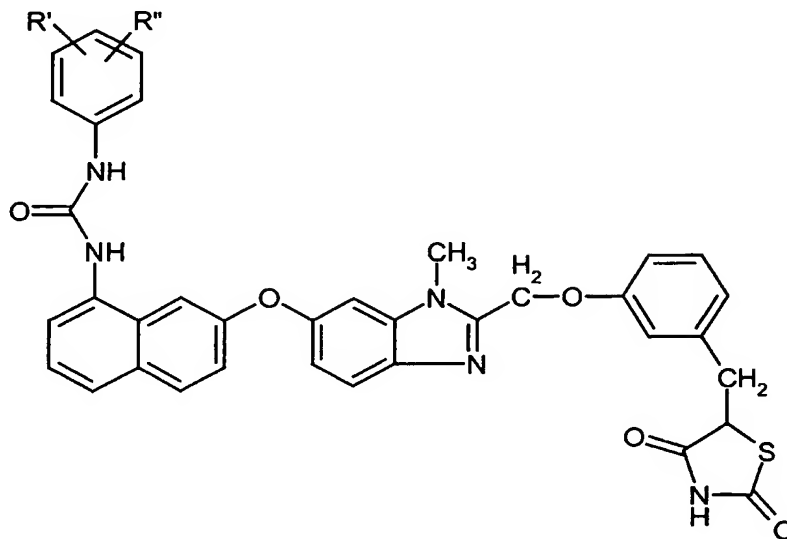
25 R^C is a hydrogen atom, an alkyl group having 1 to 4 carbon atom, an aminoalkyl, a diacid monoester or α -alkyl acid; and

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the asterisk mark * indicates a chiral carbon atom, and their pharmaceutically acceptable salts.

WO 2000/61581 discloses amine derivatives represented by the general formula:

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wherein

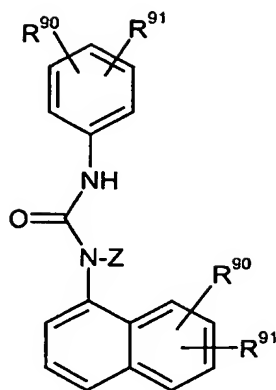
(R', R'') represent (F, F), (CF₃, H), or (iPr, iPr)

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as useful agents for diabetes, hyperlipemia, arteriosclerosis and cancer.

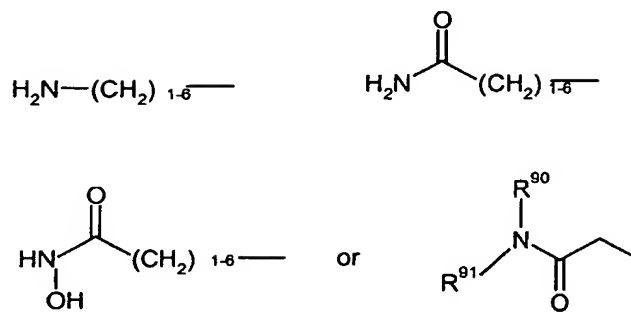
WO 00/75106 discloses the compounds represented by the general formula:

- 6 -



wherein

Z represents



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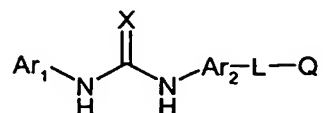
in which

10 R^{90} is hydrogen, C_{1-12} alkyl, C_{3-8} cycloalkyl, or the like, and R^{91} is amino- C_{1-6} alkyl, aminocarbonyl- C_{1-6} alkyl, or hydroxyaminocarbonyl C_{1-6} alkyl; and

15 R^{90} and R^{91} are independently selected from the group consisting of H, C_{1-6} alkyl, C_{1-6} alkylthio, C_{1-6} alkoxy, fluoro, chloro, bromo, iodo, and nitro;

as useful agents for treating MMP-mediated diseases in mammals.

WO 00/55152 discloses the compounds represented by the general formula:



5 wherein

Ar₁ is heterocycle;

Ar₂ is tetrahydronaphthyl; and

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L and Q are defined in this specification;

as useful agents for treating inflammation, immune related disease, pain and diabetes.

15 However, none of these reference discloses simple tetrahydro-naphthalene derivatives having VR1 antagonistic activity.

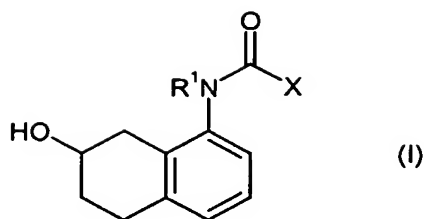
The development of a compound which has effective VR1 antagonistic activity and can be used for the prophylaxis and treatment of diseases associated with VR1
20 activity, in particular for the treatment of urinary incontinence such as urge urinary incontinence, overactive bladder, as well as pain, and/or inflammatory diseases such as asthma and COPD has been desired.

SUMMARY OF THE INVENTION

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This invention is to provide a tetrahydro-naphthalene derivative of the formula (I), their tautomeric and stereoisomeric form, and salts thereof:

- 8 -



wherein

R^1 represents hydrogen or C_{1-6} alkyl;

X represents $-N(H)Y^1$, $-N(H)-C_{1-6}$ alkylene Y^1 , biphenyl or C_{1-6} alkyl substituted by biphenyl;

wherein

said biphenyl is substituted by Z^1 , Z^2 and Z^3 ;

Y^1 represents biphenyl substituted by Z^3 , Z^4 and Z^5 ;

Z^1 and Z^2 are identical or different and represent hydrogen, halogen, carboxy, nitro, C_{1-6} alkyl optionally substituted by cyano or mono-, di-, or tri- halogen, C_{1-6} alkoxy optionally substituted by morpholino, or mono-, di-, or tri- halogen, C_{1-6} alkylthio, amino, C_{1-6} alkylamino, di(C_{1-6} alkyl)amino, C_{1-6} alkylsulfinyl, C_{1-6} alkanoyl, or C_{1-6} alkoxycarbonyl;

Z^3 represents hydrogen, halogen, amino, pyrrolidinyl, piperidino, piperazinyl, homopiperidino, C_{1-6} alkoxy optionally substituted by mono-, di-, or tri- halogen, or C_{1-6} alkyl optionally substituted by mono-, di-, or tri- halogen;

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5 Z^4 represents halogen, carboxy, nitro, C_{1-6} alkyl optionally substituted by cyano or mono-, di-, or tri- halogen, C_{1-6} alkoxy optionally substituted by morpholino, or mono-, di-, or tri- halogen, C_{1-6} alkylthio, amino, C_{1-6} alkylamino, di(C_{1-6} alkyl)-amino, C_{1-6} alkylsulfinyl, C_{1-6} alkanoyl, or C_{1-6} alkoxycarbonyl; and

10 Z^5 represents hydrogen, halogen, carboxy, nitro, C_{1-6} alkyl optionally substituted by cyano or mono-, di-, or tri- halogen, C_{1-6} alkoxy optionally substituted by morpholino, or mono-, di-, or tri- halogen, C_{1-6} alkylthio, amino, C_{1-6} alkylamino, di(C_{1-6} alkyl)amino, C_{1-6} alkylsulfinyl, C_{1-6} alkanoyl, or C_{1-6} alkoxycarbonyl;

15 or

Z^4 and Z^5 together with the carbon atom to which they are attached, form a benzene ring.

20 The tetrahydro-naphthalene derivatives of formula (I), their tautomeric and stereoisomeric form, and salts thereof surprisingly show excellent VR1 antagonistic activity. They are, therefore suitable especially for the prophylaxis and treatment of diseases associated with VR1 activity, in particular for the treatment of urinary incontinence such as urge urinary incontinence and/or overactive bladder.

25 The compounds of the present invention are also effective for treating or preventing a disease selected from the group consisting of urinary incontinence, overactive bladder, urge urinary incontinence, chronic pain, neuropathic pain, postoperative pain, rheumatoid arthritic pain, neuralgia, neuropathies, algesia, nerve injury,
30 ischaemia, neurodegeneration and/or stroke, as well as inflammatory diseases such as asthma and COPD since the diseases also relate to VR1 activity.

5 The compounds of the present invention are also useful for the treatment and prophylaxis of neuropathic pain, which is a form of pain often associated with herpes zoster and post-herpetic neuralgia, painful diabetic neuropathy, neuropathic low back pain, posttraumatic and postoperative neuralgia, neuralgia due to nerve compression and other neuralgias, phantom pain, complex regional pain syndromes, infectious or parainfectious neuropathies like those associated with HIV infection, pain associated with central nervous system disorders like multiple sclerosis or Parkinson disease or spinal cord injury or traumatic brain injury, and post-stroke pain.

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Furthermore, the compounds of the present invention are useful for the treatment of musculoskeletal pain, forms of pain often associated with osteoarthritis or rheumatoid arthritis or other forms of arthritis, and back pain.

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In addition, the compounds of the present invention are useful for the treatment of pain associated with cancer, including visceral or neuropathic pain associated with cancer or cancer treatment.

20

The compounds of the present invention are furthermore useful for the treatment of visceral pain, e.g. pain associated with obstruction of hollow viscus like gallstone colik, pain associated with irritable bowel syndrome, pelvic pain, vulvodynia, orchialgia or prostatodynia, pain associated with inflammatory lesions of joints, skin, muscles or nerves, and orofascial pain and headache, e.g. migraine or tension-type headache.

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Further, the present invention provides a medicament, which includes one of the compounds, described above and optionally pharmaceutically acceptable excipients.

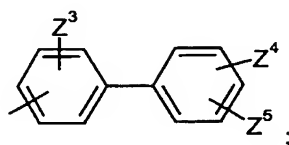
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In another embodiment, the tetrahydro-naphthalene derivatives of formula (I) are those wherein;

R¹ represents hydrogen;

X represents -N(H)Y¹ or -N(H)-C₁₋₆ alkyleneY¹;

5 Y¹ represents



10 Z³ represents hydrogen, fluoro, chloro, bromo, amino, pyrrolidinyl, piperidino, piperazinyl, homopiperidino, C₁₋₆ alkoxy optionally substituted by cyano or mono-, di-, or tri- halogen, or C₁₋₆ alkyl optionally substituted by cyano or mono-, di-, or tri- halogen;

15 Z⁴ represents halogen, carboxy, nitro, C₁₋₆ alkyl optionally substituted by cyano or mono-, di-, or tri- halogen, C₁₋₆ alkoxy optionally substituted by morpholino, or mono-, di-, or tri- halogen, C₁₋₆ alkylthio, amino, C₁₋₆ alkylamino, di(C₁₋₆ alkyl)-amino, C₁₋₆ alkylsulfinyl, C₁₋₆ alkanoyl, or C₁₋₆ alkoxycarbonyl;
20 and

25 Z⁵ represents hydrogen, halogen, carboxy, nitro, C₁₋₆ alkyl optionally substituted by cyano or mono-, di-, or tri- halogen, C₁₋₆ alkoxy optionally substituted by morpholino, or mono-, di-, or tri- halogen, C₁₋₆ alkylthio, amino, C₁₋₆ alkylamino, di(C₁₋₆ alkyl)amino, C₁₋₆ alkylsulfinyl, C₁₋₆ alkanoyl, or C₁₋₆ alkoxycarbonyl.

Yet another embodiment of formula (I) can be those wherein:

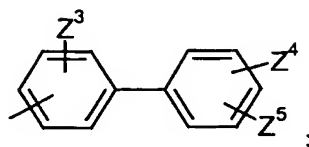
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R¹ represents hydrogen;

X represents -N(H)Y¹ or -N(H)-C₁₋₆ alkyleneY¹;

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Y¹ represents



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Z³ represents hydrogen or piperidino;

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Z⁴ represents fluoro, chloro, bromo, carboxy, nitro, C₁₋₆ alkyl optionally substituted by mono-, di-, or tri- halogen, C₁₋₆ alkoxy optionally substituted by morpholino, or mono-, di-, or tri- halogen, C₁₋₆ alkylthio, di(C₁₋₆ alkyl)amino, C₁₋₆ alkyl-sulfinyl, C₁₋₆ alkanoyl, or C₁₋₆ alkoxy-carbonyl; and

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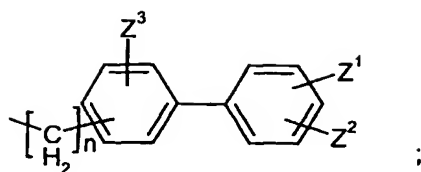
Z⁵ represents hydrogen, fluoro, chloro, bromo, C₁₋₆ alkoxy, C₁₋₆ alkylthio or C₁₋₆ alkyl optionally substituted by cyano or mono-, di-, or tri- halogen.

Further embodiment of the compounds of formula (I) is those wherein:

25

R¹ represents hydrogen;

X represents



n represents an integer selected from 0 to 6;

5 Z^1 and Z^2 are identical or different and represent hydrogen, fluoro, chloro, bromo, carboxy, nitro, C_{1-6} alkyl optionally substituted by mono-, di-, or tri- halogen, C_{1-6} alkoxy optionally substituted by morpholino, or mono-, di-, or tri- halogen, C_{1-6} alkylthio, di(C_{1-6} alkyl)amino, C_{1-6} alkylsulfinyl, C_{1-6} alkanoyl, or C_{1-6} alkoxy carbonyl; and

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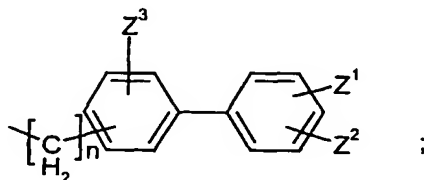
Z^3 represents hydrogen, fluoro, chloro, bromo, amino, piperidino, C_{1-6} alkoxy optionally substituted by mono-, di-, or tri- halogen, or C_{1-6} alkyl optionally substituted by cyano or mono-, di-, or tri- halogen.

15

Another embodiment of the compounds of formula (I) is those wherein:

R^1 represents hydrogen;

20 X represents



n represents an integer of 0 or 1;

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Z^1 represents hydrogen, fluoro, chloro, bromo, C_{1-6} alkyl, C_{1-6} alkoxy, amino, C_{1-6} alkylamino, or di(C_{1-6} alkyl)amino;

5 Z^2 represents hydrogen, fluoro, chloro, bromo, C_{1-6} alkyl or C_{1-6} alkoxy:
and

Z^3 represents hydrogen.

10 More preferably, said tetrahydro-naphthalene derivative of the formula (I) is selected from the group consisting of:

N-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)-N'-[4'-(trifluoromethyl)biphenyl-3-yl]urea;

15 N-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)-N'-[2'-(trifluoromethyl)biphenyl-3-yl]urea;

N-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)-N'-[4'-(methylthio)biphenyl-3-yl]urea;

N-(2',3'-dichlorobiphenyl-3-yl)-N'-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)urea;

20 N-(2',4'-dichlorobiphenyl-3-yl)-N'-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)urea;

N-(4'-acetylbiphenyl-3-yl)-N'-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)urea;

N-[(2'-fluorobiphenyl-4-yl)methyl]-N'-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)urea;

25 N-[(2'-fluorobiphenyl-4-yl)methyl]-N'-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)urea;

N-[(2',6'-difluorobiphenyl-4-yl)methyl]-N'-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)urea;

30 N-[(2'-fluorobiphenyl-3-yl)methyl]-N'-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)urea;

N-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)-N'-[(4'-isopropylbiphenyl-3-yl)methyl]urea;

N-[(2',4'-dichlorobiphenyl-3-yl)methyl]-N'-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)urea.

5

The Alkyl per se and "alk" and "alkyl" in alkoxy, alkanoyl, alkylamino, alkylamino-carbonyl, alkylaminosulphonyl, alkylsulphonylamino, alkoxy-carbonyl, alkoxy-carbonylamino and alkanoylamino represent a linear or branched alkyl radical having generally 1 to 6, preferably 1 to 4 and particularly preferably 1 to 3 carbon atoms, representing illustratively and preferably methyl, ethyl, n-propyl, isopropyl, tert-butyl, n-pentyl and n-hexyl.

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Alkoxy illustratively and preferably represents methoxy, ethoxy, n-propoxy, isopropoxy, tert-butoxy, n-pentoxy and n-hexoxy.

15

Alkylamino illustratively and preferably represents an alkylamino radical having one or two (independently selected) alkyl substituents, illustratively and preferably representing methylamino, ethylamino, n-propylamino, isopropylamino, tert-butylamino, n-pentylamino, n-hexyl-amino, N,N-dimethylamino, N,N-diethylamino, N-ethyl-N-methylamino, N-methyl-N-n-propylamino, N-isopropyl-N-n-propylamino, N-t-butyl-N-methylamino, N-ethyl-N-n-pentylamino and N-n-hexyl-N-methylamino.

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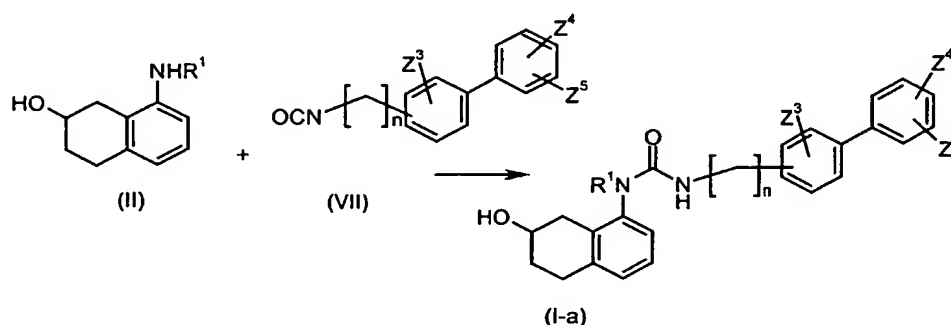
EMBODIMENT OF THE INVENTION

The compound of the formula (I) of the present invention can be, but not limited to be, prepared by combining various known methods. In some embodiments, one or more of the substituents, such as amino group, carboxyl group, and hydroxyl group of the compounds used as starting materials or intermediates are advantageously protected by a protecting group known to those skilled in the art. Examples of the protecting groups are described in "Protective Groups in Organic Synthesis (3rd Edition)" by Greene and Wuts, John Wiley and Sons, New York 1999.

30

The compound of the formula (I) of the present invention can be, but not limited to be, prepared by the Method [A], [B], [C], [D], [E], [F], [G], [H], [I] or [J] below.

5 [Method A]



10 The compound of the formula (I-a) (wherein R^1 , Z^3 , Z^4 , and Z^5 are the same as defined above and n represents an integer of 0 to 6) can be prepared by the reaction of the compound of the formula (II) (wherein R^1 is the same as defined above) and the compound of the formula (VII) (wherein Z^3 , Z^4 , and Z^5 are the same as defined above and n represents an integer of 0 to 6).

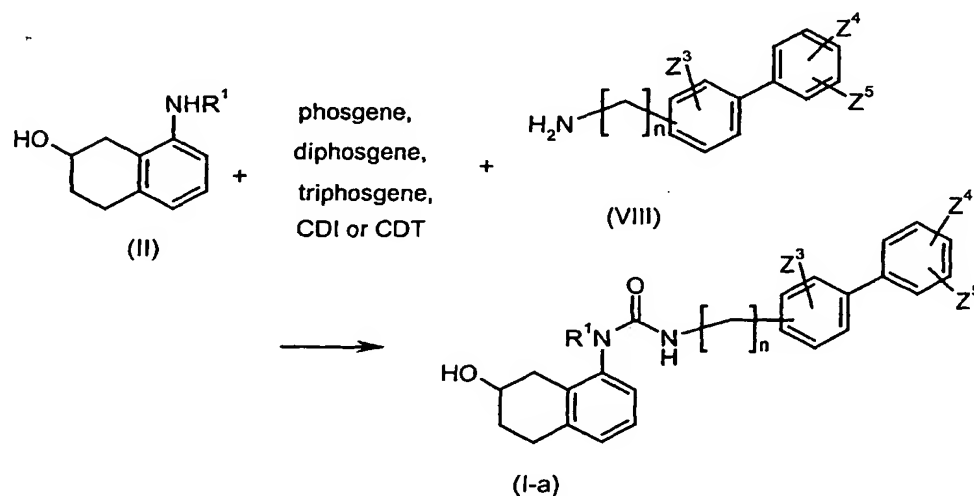
15 The reaction may be carried out in a solvent including, for instance, halogenated hydrocarbons such as dichloromethane, chloroform and 1,2-dichloroethane; ethers such as diethyl ether, isopropyl ether, dioxane and tetrahydrofuran (THF) and 1,2-dimethoxyethane; aromatic hydrocarbons such as benzene, toluene and xylene; nitriles such as acetonitrile; amides such as N, N-dimethylformamide (DMF), N, N-dimethylacetamide (DMAC) and N-methylpyrrolidone (NMP); urea such as 1,3-dimethyl-2-imidazolidinone (DMI); sulfoxides such as dimethylsulfoxide (DMSO);
 20 and others. Optionally, two or more of the solvents selected from the listed above can be mixed and used.

The reaction can be carried out in the presence of organic base such as pyridine or triethylamine.

The reaction temperature can be optionally set depending on the compounds to be reacted. The reaction temperature is usually, but not limited to, about room temperature to 100°C. The reaction may be conducted for, usually, 30 minutes to 48 hours and preferably 1 to 24 hours.

The compound (II) and (VII) can be prepared by the use of known techniques or are commercially available.

[Method B]



15

The compound of the formula (I-a) (wherein n , R^1 , Z^3 , Z^4 , and Z^5 are the same as defined above) can be prepared by reacting the compound of the formula (II) (wherein R^1 is the same as defined above) with phosgene, diphosgene, triphosgene, 1,1-carbonyldiimidazole (CDI), or 1,1'-carbonyldi(1,2,4-triazole)(CDT), and then adding the compound of the formula (VIII) (wherein n , Z^3 , Z^4 , and Z^5 are the same as defined above) to the reaction mixture.

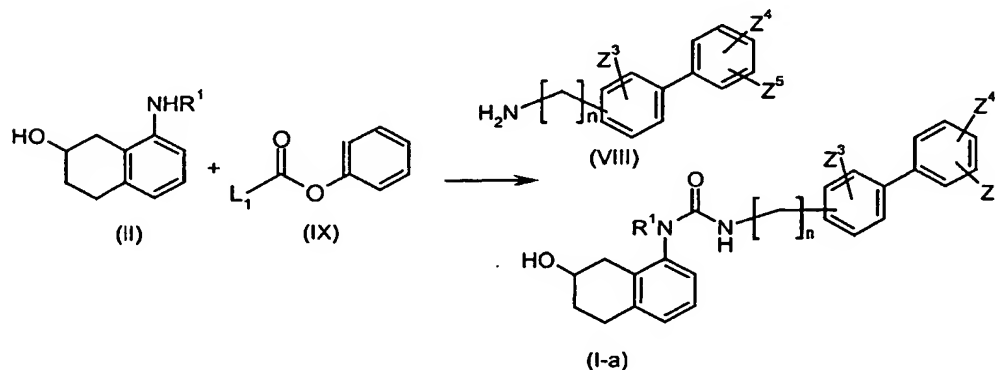
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The reaction may be carried out in a solvent including, for instance, halogenated hydrocarbons such as dichloromethane, chloroform and 1,2-dichloroethane; ethers such as diethyl ether, isopropyl ether, dioxane and tetrahydrofuran (THF) and 1,2-dimethoxyethane; aromatic hydrocarbons such as benzene, toluene and xylene; nitriles such as acetonitrile; amides such as N, N-dimethylformamide (DMF), N, N-dimethylacetamide (DMAC) and N-methylpyrrolidone (NMP); urea such as 1,3-dimethyl-2-imidazolidinone (DMI); sulfoxides such as dimethylsulfoxide (DMSO); and others. Optionally, two or more of the solvents selected from the listed above can be mixed and used.

The reaction temperature can be optionally set depending on the compounds to be reacted. The reaction temperature is usually, but not limited to, about 20°C to 50°C. The reaction may be conducted for, usually, 30 minutes to 10 hours and preferably 1 to 24 hours.

Phosgene, diphosgene, triphosgene, CDI, CDT and the compound (VIII) are commercially available or can be prepared by the use of known techniques.

[Method C]



The compound of the formula (I-a) (wherein n, R¹, Z³, Z⁴, and Z⁵ are the same as defined above) can be prepared by reacting the compound of the formula (II)

(wherein R^1 is the same as defined above) and the compound of the formula (IX) (wherein L_1 represents halogen atom such as chlorine, bromine, or iodine atom) and then adding the compound of the formula (VIII) (wherein n , Z^3 , Z^4 , and Z^5 are the same as defined above) to the reaction mixture.

5

The reaction may be carried out in a solvent including, for instance, halogenated hydrocarbons such as dichloromethane, chloroform and 1,2-dichloroethane; ethers such as diethyl ether, isopropyl ether, dioxane and tetrahydrofuran (THF) and 1,2-dimethoxyethane; aromatic hydrocarbons such as benzene, toluene and xylene; nitriles such as acetonitrile; amides such as N, N-dimethylformamide (DMF), N, N-dimethylacetamide (DMAC) and N-methylpyrrolidone (NMP); urea such as 1,3-dimethyl-2-imidazolidinone (DMI); sulfoxides such as dimethylsulfoxide (DMSO); and others. Optionally, two or more of the solvents selected from the listed above can be mixed and used.

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The reaction temperature can be optionally set depending on the compounds to be reacted. The reaction temperature is usually, but not limited to, about 20°C to 50°C. The reaction may be conducted for, usually, 30 minutes to 10 hours and preferably 1 to 24 hours.

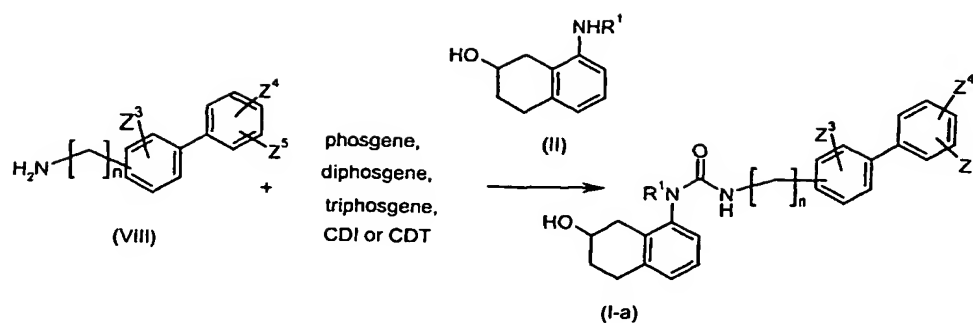
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The reaction can be advantageously carried out in the presence of a base including, for instance, organic amines such as pyridine, triethylamine and N,N-diisopropylethylamine, dimethylaniline, diethylaniline, 4-dimethylaminopyridine, and others.

25

The compound (IX) is commercially available or can be prepared by the use of known techniques.

[Method D]



5 The compound of the formula (I-a) (wherein n , R^1 , Z^3 , Z^4 , and Z^5 are the same as defined above) can be prepared by reacting the compound of the formula (VIII) (wherein n , Z^3 , Z^4 , and Z^5 are the same as defined above) with phosgene, diphosgene, triphosgene, 1,1-carbonyldiimidazole (CDI), or 1,1'-carbonyldi(1,2,4-triazole)(CDT), and then adding the compound of the formula (II) (wherein R^1 is the same as defined above) to the reaction mixture.

10

The reaction may be carried out in a solvent including, for instance, halogenated hydrocarbons such as dichloromethane, chloroform and 1,2-dichloroethane; ethers such as diethyl ether, isopropyl ether, dioxane and tetrahydrofuran (THF) and 1,2-dimethoxyethane; aromatic hydrocarbons such as benzene, toluene and xylene; nitriles such as acetonitrile; amides such as N, N-dimethylformamide (DMF), N, N-dimethylacetamide (DMAC) and N-methylpyrrolidone (NMP); urea such as 1,3-dimethyl-2-imidazolidinone (DMI); sulfoxides such as dimethylsulfoxide (DMSO); and others. Optionally, two or more of the solvents selected from the listed above can be mixed and used.

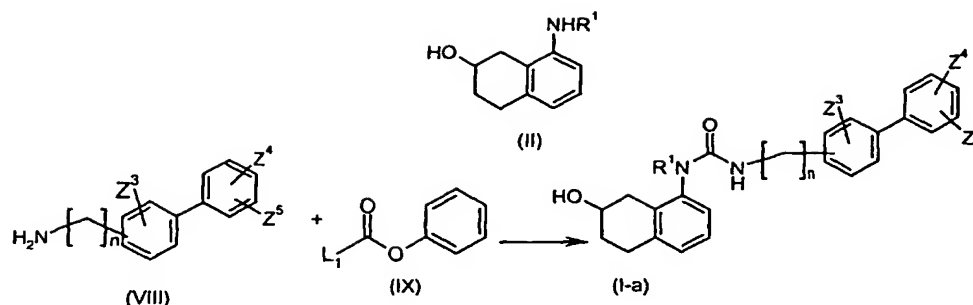
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The reaction temperature can be optionally set depending on the compounds to be reacted. The reaction temperature is usually, but not limited to, about 20°C to 50°C. The reaction may be conducted for, usually, 30 minutes to 10 hours and preferably 1 to 24 hours.

25

[Method E]



5

The compound of the formula (I-a) (wherein n , R^1 , Z^3 , Z^4 , and Z^5 are the same as defined above) can be prepared by reacting the compound of the formula (VIII) (wherein n , Z^3 , Z^4 , and Z^5 are the same as defined above) and the compound of the formula (IX) (wherein L_1 is the same as defined above), and then adding the compound of the formula (II) (wherein R^1 is the same as defined above) to the reaction mixture.

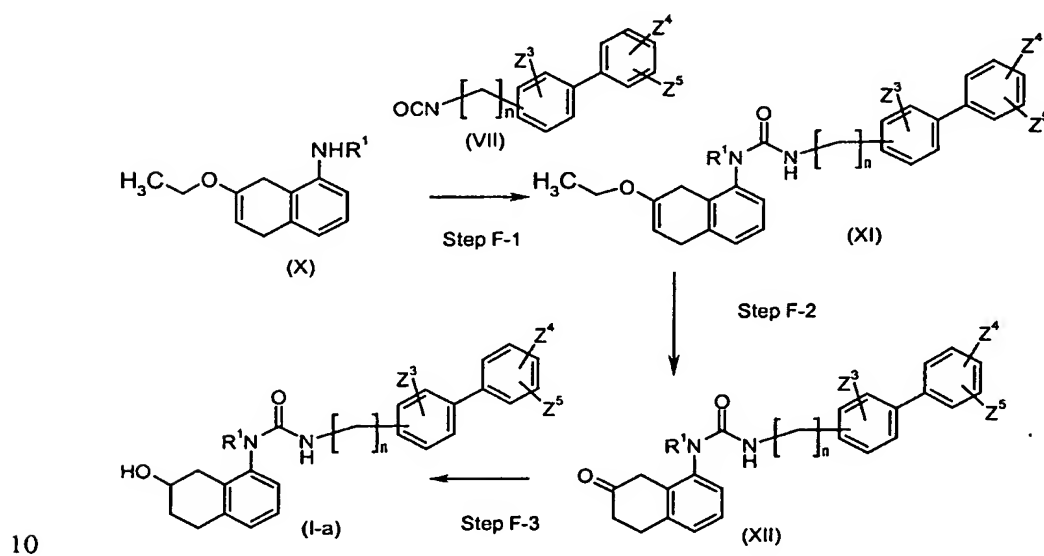
The reaction may be carried out in a solvent including, for instance, halogenated hydrocarbons such as dichloromethane, chloroform and 1,2-dichloroethane; ethers such as diethyl ether, isopropyl ether, dioxane and tetrahydrofuran (THF) and 1,2-dimethoxyethane; aromatic hydrocarbons such as benzene, toluene and xylene; nitriles such as acetonitrile; amides such as N, N-dimethylformamide (DMF), N, N-dimethylacetamide (DMAC) and N-methylpyrrolidone (NMP); urea such as 1,3-dimethyl-2-imidazolidinone (DMI); sulfoxides such as dimethylsulfoxide (DMSO); and others. Optionally, two or more of the solvents selected from the listed above can be mixed and used.

The reaction temperature can be optionally set depending on the compounds to be reacted. The reaction temperature is usually, but not limited to, about 20°C to 50°C .

The reaction may be conducted for, usually, 30 minutes to 10 hours and preferably 1 to 24 hours.

The reaction can be advantageously carried out in the presence of a base including, for instance, organic amines such as pyridine, triethylamine and N,N-diisopropylethylamine, dimethylaniline, diethylaniline, 4-dimethylaminopyridine, and others.

[Method F]



The compound of the formula (I-a) (wherein n, R¹, Z³, Z⁴, and Z⁵ are the same as defined above) can be prepared by the following procedures in three steps;

15 In the Step F-1, the compound of the formula (XI) (wherein R¹, Z³, Z⁴, and Z⁵ are the same as defined above and n represents an integer of 0 to 6) can be prepared by reacting the compound of the formula (X) (wherein R¹ is the same as defined above) with the compound of the formula (VII) (wherein n, R¹, Z³, Z⁴, and Z⁵ are the same as defined above) in a similar manner described in Method A for the preparation of

20 the compound of the formula (I-a).

In the Step F-2, the compound of the formula (XII) (wherein n , R^1 , Z^3 , Z^4 , and Z^5 are the same as defined above) can be prepared by reacting the compound of the formula (XI) (wherein n , R^1 , Z^3 , Z^4 , and Z^5 are the same as defined above) with an acid such as hydrochloric acid.

The reaction may be carried out in a solvent including, for instance, halogenated hydrocarbons such as dichloromethane, chloroform and 1,2-dichloroethane; ethers such as diethyl ether, isopropyl ether, dioxane and tetrahydrofuran (THF) and 1,2-dimethoxyethane; alcohols such as methanol, ethanol; water and others. Optionally, two or more of the solvents selected from the listed above can be mixed and used.

The reaction temperature can be optionally set depending on the compounds to be reacted. The reaction temperature is usually, but not limited to, about 20°C to 100°C. The reaction may be conducted for, usually, 30 minutes to 10 hours and preferably 1 to 24 hours.

In the Step F-3, the compound of the formula (I-a) (wherein n , R^1 , Z^3 , Z^4 , and Z^5 are the same as defined above) can be prepared by reacting the compound of the formula (XII) (wherein n , R^1 , Z^3 , Z^4 , and Z^5 are the same as defined above) with reducing agent such as sodium borohydride or lithium aluminum hydride.

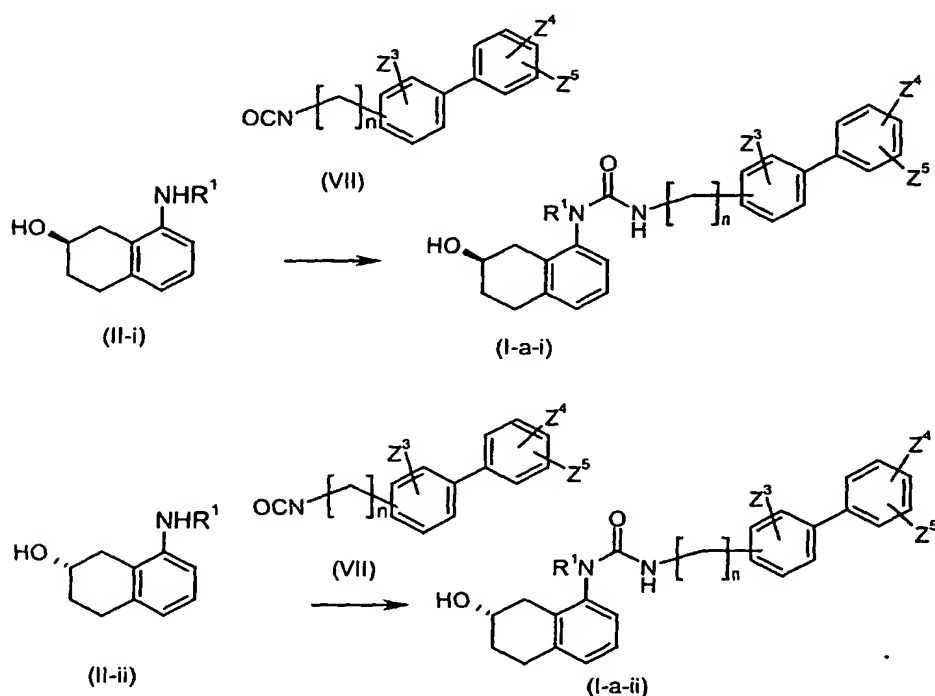
The reaction may be carried out in a solvent including, for instance, ethers such as diethyl ether, isopropyl ether, dioxane and tetrahydrofuran (THF) and 1,2-dimethoxyethane; alcohols such as methanol, ethanol, isopropanol, and others. Optionally, two or more of the solvents selected from the listed above can be mixed and used.

The reaction temperature can be optionally set depending on the compounds to be reacted. The reaction temperature is usually, but not limited to, about 20°C to 50°C.

The reaction may be conducted for, usually, 30 minutes to 10 hours and preferably 1 to 24 hours.

The compound (X) is commercially available or can be prepared by the use of known techniques.

[Method G]



10

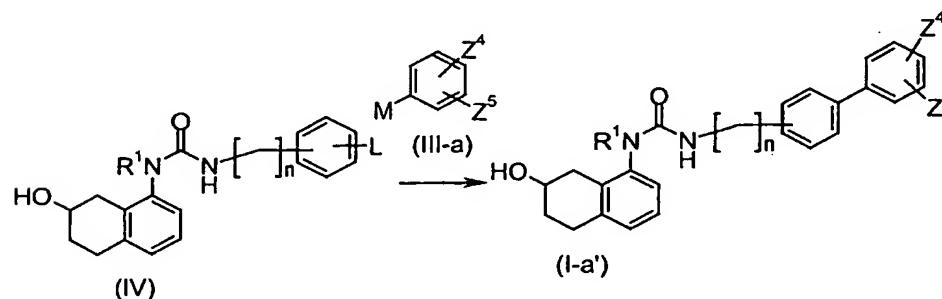
The stereoisomeric form of the compound (I-a), R form (I-a-i) (wherein n , R^1 , Z^3 , Z^4 , and Z^5 are the same as defined above) can be prepared by the reaction of the compound of the formula (II-i) (wherein R^1 is the same as defined above) with the compound of the formula (VII) (wherein n , Z^3 , Z^4 , and Z^5 are the same as defined above) in a similar manner described in Method A for the preparation of the compound of the formula (I-a).

15

The stereoisomeric form of the compound (I-a), S form (I-a-ii) (wherein n , R^1 , Z^3 , Z^4 , and Z^5 are the same as defined above) can be prepared by the reaction of the compound of (II-ii) (wherein R^1 is the same as defined above) with the compound of the formula (VII) (wherein n , R^1 , Z^3 , Z^4 , and Z^5 are the same as defined above) in a similar manner described in Method A for the preparation of the compound of the formula (I-a).

The compound (II-i) or (II-ii) can be prepared by the use of known techniques.

10 [Method H]



The compound of the formula (I-a') (wherein R^1 , Z^4 and Z^5 are the same as defined above and n represents an integer of 0 to 6) can be obtained by the reaction of the compound of the formula (IV) (wherein n and R^1 are the same as defined above and L represents a leaving group including, for example, halogen atom such as chlorine, bromine, or iodine atom; and C_{1-4} alkylsulfonyloxy group, e.g., trifluoromethanesulfonyloxy, methanesulfonyloxy and the like) with the compound of the formula (III-a) (wherein Z^4 and Z^5 are the same as defined above and M represents metal group including, for instance, organoborane group such as boronic acid and dimethoxy boryl; organostannyl group such as tributyl stannyl, and the like.) in the presence of a palladium catalyst such as tetrakis(triphenylphosphine)palladium.

The reaction can be advantageously carried out in the presence of a base including, for instance, cesium carbonate, sodium carbonate and potassium carbonate, barium hydroxide and the like.

5 The reaction may be carried out in a solvent including, for instance, ethers such as diethyl ether, isopropyl ether, dioxane and tetrahydrofuran (THF) and 1,2-dimethoxyethane; aromatic hydrocarbons such as benzene, toluene and xylene; amides such as N, N-dimethylformamide (DMF), N, N-dimethylacetamide and N-methylpyrrolidone; sulfoxides such as dimethylsulfoxide (DMSO); alcohols such as methanol,
 10 ethanol, 1-propanol, isopropanol and tert-butanol; water and others. Optionally, two or more of the solvents selected from the listed above can be mixed and used.

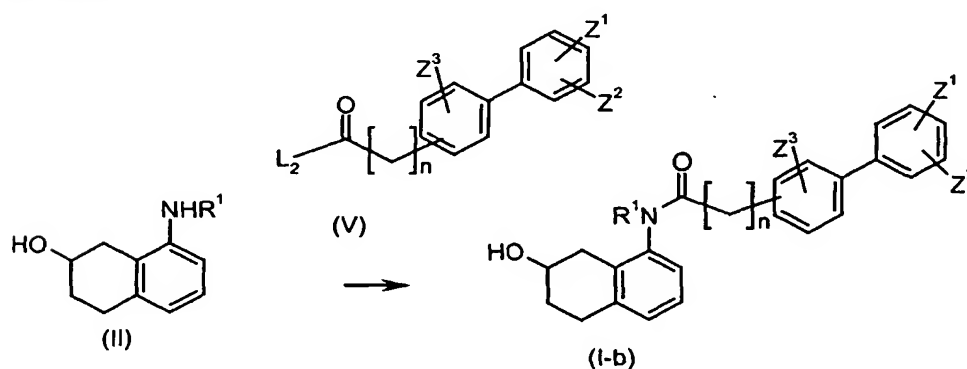
The reaction temperature can be optionally set depending on the compounds to be reacted. The reaction temperature is usually, but not limited to, about 20°C to 120°C.

15 The reaction may be conducted for, usually, 30 minutes to 48 hours and preferably 1 to 24 hours.

The compound (III-a) is commercially available or can be prepared by the use of known techniques.

20

[Method I]



The compound (I-b) (wherein n , R^1 , Z^1 , Z^2 , and Z^3 are the same as defined above and n represents an integer of 0 to 6), can be prepared by the reaction of the compound of the formula (II) (wherein R^1 is the same as defined above) with the compound of the formula (V) (wherein Z^1 , Z^2 , and Z^3 are the same as defined above, n represents an integer of 0 to 6 and L_2 represents a leaving group including, for instance, hydroxy or halogen atom such as chlorine, bromine, or iodine atom).

The reaction may be carried out in a solvent including, for instance, halogenated hydrocarbons such as dichloromethane, chloroform and 1,2-dichloroethane; ethers such as diethyl ether, isopropyl ether, dioxane and tetrahydrofuran (THF) and 1,2-dimethoxyethane; aromatic hydrocarbons such as benzene, toluene and xylene; nitriles such as acetonitrile; amides such as N, N-dimethylformamide (DMF), N, N-dimethylacetamide (DMAC) and N-methylpyrrolidone (NMP); urea such as 1,3-dimethyl-2-imidazolidinone (DMI); sulfoxides such as dimethylsulfoxide (DMSO); and others. Optionally, two or more of the solvents selected from the listed above can be mixed and used.

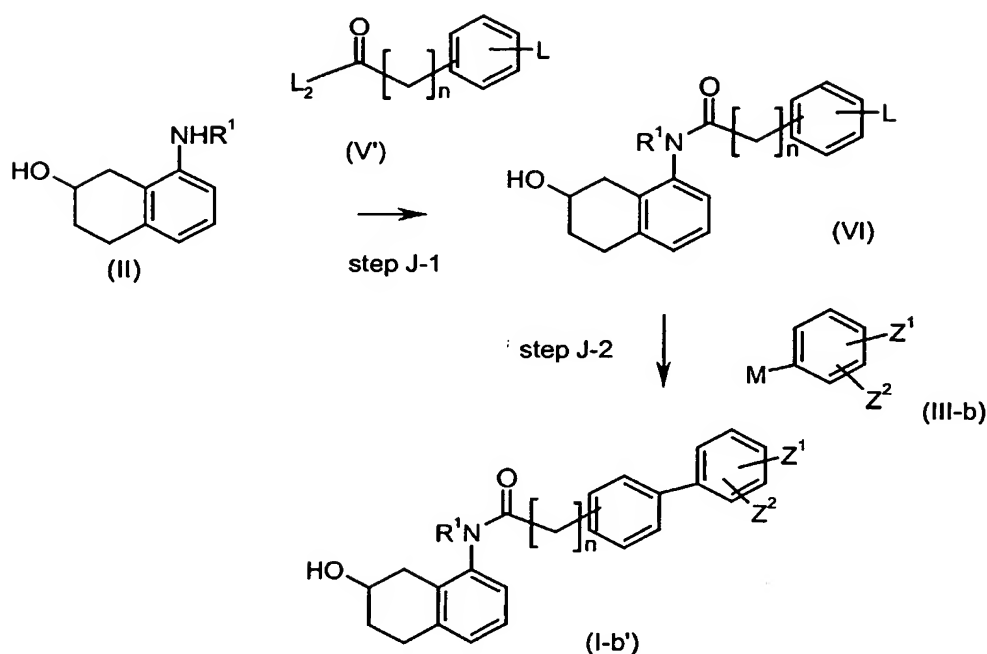
The reaction temperature can be optionally set depending on the compounds to be reacted. The reaction temperature is usually, but not limited to, about 0°C to 50°C. The reaction may be conducted for, usually, 30 minutes to 10 hours and preferably 1 to 24 hours.

The reaction can be advantageously carried out in the presence of a base including, for instance, organic amines such as pyridine, triethylamine and N,N-diisopropylethylamine, dimethylaniline, diethylaniline, 4-dimethylaminopyridine, and others.

When L_2 is hydroxy, the reaction can be advantageously carried out using coupling agent including, for instance, hydroxybenzotriazole, carbodiimides such as N, N-dicyclohexylcarbodiimide and 1-(3-dimethyl-aminopropyl)-3-ethylcarbodiimide; carbonyldiazoles such as 1,1'-carbonyldi(1,3-imiazole)(CDI) and 1,1'-carbonyldi(1,2,4-triazole)(CDT), and the like.

The compound (V) is commercially available or can be prepared by the use of known techniques.

5 [Method J]



10 The compound (I-b') wherein (wherein R^1 , Z^1 and Z^2 are the same as defined above and n represents an integer of 0 to 6), can be obtained by in two steps;

15 In the step J-1, the compound of the formula (VI) (wherein n and R^1 are the same as defined above), can be prepared by the reaction of the compound of the formula (II) (wherein R^1 is the same as defined above) with the compound of the formula (V') (wherein L is a leaving group as defined above, n represents an integer of 0 to 6 and L_2 represents a leaving group including, for instance, hydroxy or halogen atom such as chlorine, bromine, or iodine atom;) in a similar manner described in Method I for the preparation of the compound of the formula (I-b).

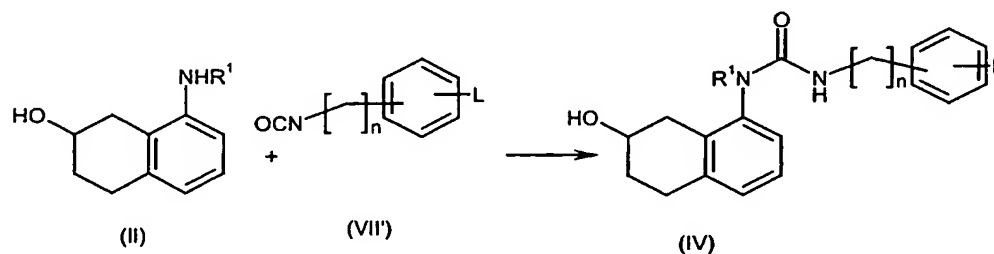
In the step J-2, the compound of the formula (I-b') (wherein R^1 , Z^1 , Z^2 and n are the same as defined above), can be prepared by the reaction of the compound of the formula (VI) (wherein R^1 , L and n are the same as defined above) with the compound of the formula (III-b) (wherein Z^1 , Z^2 and M are the same as defined above) in a similar manner described in Method A for the preparation of the compound of the formula (I-a).

The compound (V') and (III-b) are commercially available or can be prepared by the use of known techniques.

Preparation of the compound of the formula (IV)

The compound of the formula (IV) of the present invention can be, but not limited to be, prepared by Method [K], [L], [M], [N], [O], [P] or [Q] below.

[Method K]

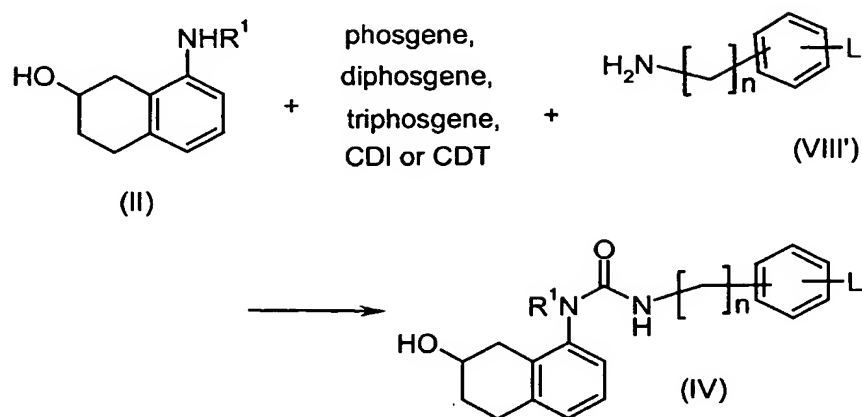


The compound of the formula (IV) (wherein n , R^1 and L are the same as defined above) can be prepared by the reaction of the compound of the formula (II) (wherein R^1 is the same as defined above) and the compound of the formula (VII') (wherein L is the same as defined above and n represents an integer of 0 to 6) in a similar manner described in Method A for the preparation of the compound of the formula (I-a).

The compound (VII') can be prepared by the use of known techniques or is commercially available.

[Method L]

5

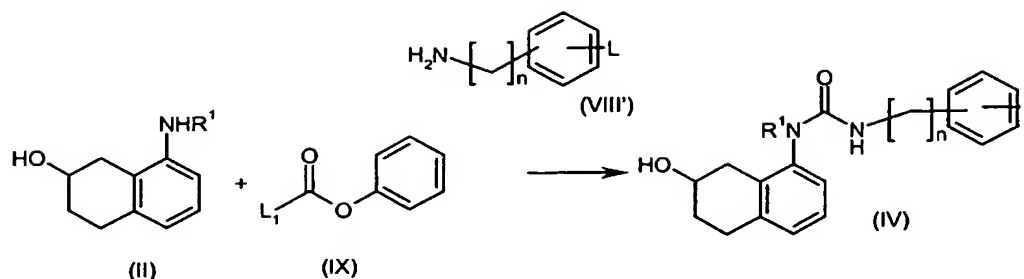


The compound (IV) (wherein n , R^1 and L are the same as defined above) can be prepared by reacting the compound of the formula (II) (wherein R^1 is the same as defined above) with phosgene, diphosgene, triphosgene, 1,1-carbonyldiimidazole (CDI), or 1,1'-carbonyldi(1,2,4-triazole) (CDT), and then adding the compound of the formula (VIII') (wherein L is the same as defined above and n represents an integer of 0 to 6) to the reaction mixture in a similar manner described in Method B for the preparation of the compound of the formula (I-a).

15

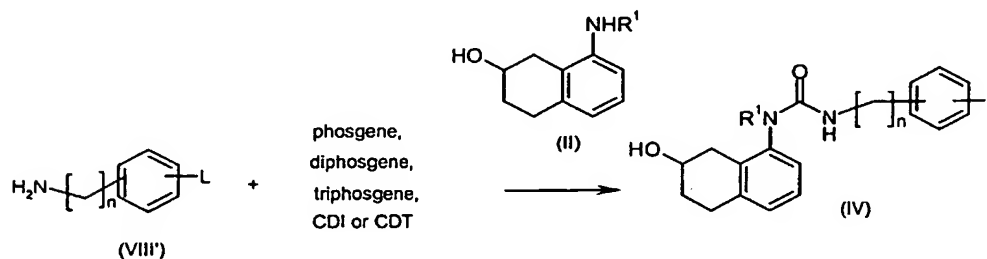
The compound (VIII') is commercially available or can be prepared by the use of known techniques.

[Method M]



- 5 The compound (IV) (wherein n , R^1 and L are the same as defined above) can be prepared by reacting the compound of the formula (II) (wherein R^1 is the same as defined above) and the compound of the formula (IX) (wherein L_1 is the same as defined above) and then adding the compound of the formula (VIII') (wherein L and n are the same as defined above) to the reaction mixture in a similar manner
- 10 described in Method C for the preparation of the compound of the formula (I-a).

[Method N]



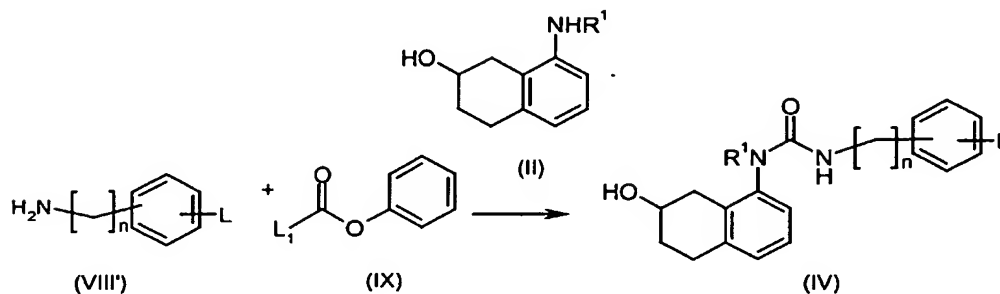
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- The compound (IV) (wherein n , R^1 and L are the same as defined above) can be prepared by reacting the compound of the formula (VIII') (wherein L and n are the same as defined above) with phosgene, diphosgene, triphosgene, 1,1-carbonyldiimidazole (CDI), or 1,1'-carbonyldi(1,2,4-triazole)(CDT), and then adding the
- 20 compound of the formula (II) (wherein R^1 is the same as defined above) to the

reaction mixture in a similar manner described in Method D for the preparation of the compound of the formula (I-a).

[Method O]

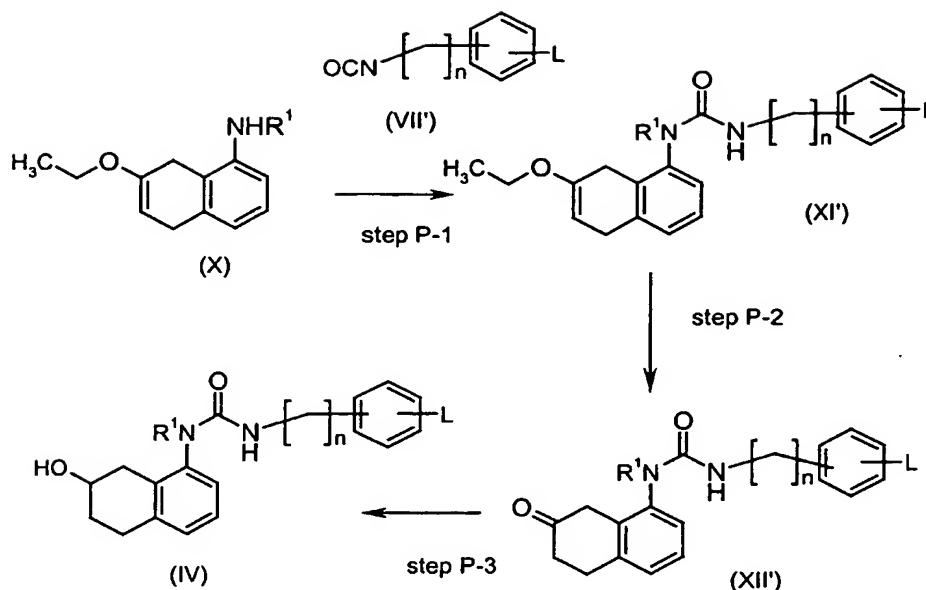
5



The compound (IV) (wherein n, R¹ and L are the same as defined above) can be prepared by reacting the compound of the formula (VIII') (wherein L and n are the same as defined above) and the compound of the formula (IX) (wherein L₁ is the same as defined above), and then adding the compound of the formula (II) (wherein R¹ is the same as defined above) to the reaction mixture in a similar manner described in Method E for the preparation of the compound of the formula (I-a).

10

[Method P]



- 5 The compound (IV) (wherein n , R^1 and L are the same as defined above) can be prepared by the following procedures in three steps;

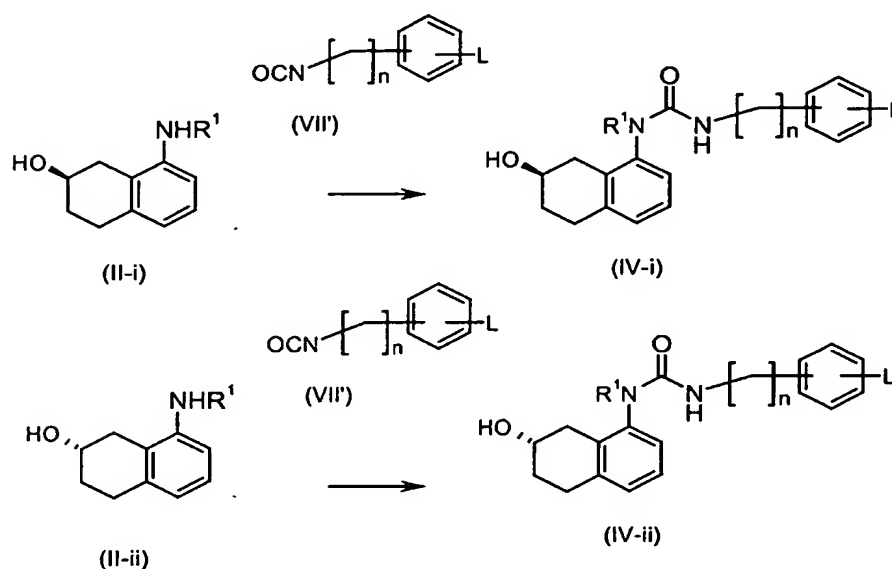
10 In the step P-1, the compound of the formula (XI') (wherein n , R^1 and L are the same as defined above) can be prepared by reacting the compound of the formula (X) (wherein R^1 is the same as defined above) with the compound of the formula (VII') (wherein L and n are the same as defined above) in a similar manner described in Method A for the preparation of the compound of the formula (I-a).

15 In the step P-2, the compound of the formula (XII') (wherein n , R^1 and L are the same as defined above) can be prepared by reacting the compound of the formula (XI') (wherein n , R^1 and L are the same as defined above) with an acid such as hydrochloric acid in a similar manner described in Method F step F-2 for the preparation of the compound of the formula (XII).

- 34 -

In the step P-3: the compound of the formula (IV) (wherein n , R^1 and L are the same as defined above) can be prepared by reacting the compound of the formula (XII') (wherein n , R^1 and L are the same as defined above) with reducing agent such as sodium borohydride or lithium aluminum hydride in a similar manner described in Method F step F-3 for the preparation of the compound of the formula (I-a)

[Method Q]



10

The stereoisomeric form of the compound (IV), R form (IV-i) (wherein n , R^1 and L are the same as defined above) can be prepared by the reaction of the compound of the formula (II-i) (wherein R^1 is the same as defined above) with the compound of the formula (VII') (wherein L and n are the same as defined above) in a similar manner described in Method A for the preparation of the compound of the formula (I-a).

15

The stereoisomeric form of the compound (IV), S form (IV-ii) (wherein n , R^1 and L are the same as defined above) can be prepared by the reaction of the compound of (II-ii) (wherein R^1 is the same as defined above) with the compound of the formula

20

(VII') (wherein L and n are the same as defined above) in a similar manner described in Method A for the preparation of the compound of the formula (I-a).

5 When the compound shown by the formula (I) or a salt thereof has an asymmetric carbon in the structure, their optically active compounds and racemic mixtures are also included in the scope of the present invention.

10 When the compound shown by the formula (I) or a salt thereof has an asymmetric carbon in the structure, their optically active compounds and racemic mixtures are also included in the scope of the present invention.

15 Typical salts of the compound shown by the formula (I) include salts prepared by reaction of the compounds of the present invention with a mineral or organic acid, or an organic or inorganic base. Such salts are known as acid addition and base addition salts, respectively.

20 Acids to form acid addition salts include inorganic acids such as, without limitation, sulfuric acid, phosphoric acid, hydrochloric acid, hydrobromic acid, hydriodic acid and the like, and organic acids, such as, without limitation, p-toluenesulfonic acid, methanesulfonic acid, oxalic acid, p-bromophenylsulfonic acid, carbonic acid, succinic acid, citric acid, benzoic acid, acetic acid, and the like.

25 Base addition salts include those derived from inorganic bases, such as, without limitation, ammonium hydroxide, alkaline metal hydroxide, alkaline earth metal hydroxides, carbonates, bicarbonates, and the like, and organic bases, such as, without limitation, ethanolamine, triethylamine, tris(hydroxymethyl)aminomethane, and the like. Examples of inorganic bases include sodium hydroxide, potassium hydroxide, potassium carbonate, sodium carbonate, sodium bicarbonate, potassium bicarbonate, calcium hydroxide, calcium carbonate, and the like.

30

The compound of the present invention or a salt thereof, depending on its substituents, may be modified to form lower alkylesters or known other esters; and/or hydrates or other solvates. Those esters, hydrates, and solvates are included in the scope of the present invention.

5

The compound of the present invention may be administered in oral forms, such as, without limitation normal and enteric coated tablets, capsules, pills, powders, granules, elixirs, tinctures, solution, suspensions, syrups, solid and liquid aerosols and emulsions. They may also be administered in parenteral forms, such as, without
10 limitation, intravenous, intraperitoneal, subcutaneous, intramuscular, and the like forms, well-known to those of ordinary skill in the pharmaceutical arts. The compounds of the present invention can be administered in intranasal form via topical use of suitable intranasal vehicles, or via transdermal routes, using transdermal delivery systems well-known to those of ordinary skilled in the art.

15

The dosage regimen with the use of the compounds of the present invention is selected by one of ordinary skill in the arts, in view of a variety of factors, including, without limitation, age, weight, sex, and medical condition of the recipient, the severity of the condition to be treated, the route of administration, the level of
20 metabolic and excretory function of the recipient, the dosage form employed, the particular compound and salt thereof employed.

The compounds of the present invention are preferably formulated prior to administration together with one or more pharmaceutically-acceptable excipients.
25 Excipients are inert substances such as, without limitation carriers, diluents, flavoring agents, sweeteners, lubricants, solubilizers, suspending agents, binders, tablet disintegrating agents and encapsulating material.

Yet another embodiment of the present invention is pharmaceutical formulation
30 comprising a compound of the invention and one or more pharmaceutically-acceptable excipients that are compatible with the other ingredients of the

formulation and not deleterious to the recipient thereof. Pharmaceutical formulations of the invention are prepared by combining a therapeutically effective amount of the compounds of the invention together with one or more pharmaceutically-acceptable excipients therefore. In making the compositions of the present invention, the active
5 ingredient may be mixed with a diluent, or enclosed within a carrier, which may be in the form of a capsule, sachet, paper, or other container. The carrier may serve as a diluent, which may be solid, semi-solid, or liquid material which acts as a vehicle, or can be in the form of tablets, pills powders, lozenges, elixirs, suspensions, emulsions, solutions, syrups, aerosols, ointments, containing, for example, up to 10% by weight
10 of the active compound, soft and hard gelatin capsules, suppositories, sterile injectable solutions and sterile packaged powders.

For oral administration, the active ingredient may be combined with an oral, and non-toxic, pharmaceutically-acceptable carrier, such as, without limitation, lactose,
15 starch, sucrose, glucose, sodium carbonate, mannitol, sorbitol, calcium carbonate, calcium phosphate, calcium sulfate, methyl cellulose, and the like; together with, optionally, disintegrating agents, such as, without limitation, maize, starch, methyl cellulose, agar bentonite, xanthan gum, alginic acid, and the like; and optionally, binding agents, for example, without limitation, gelatin, natural sugars, beta-lactose,
20 corn sweeteners, natural and synthetic gums, acacia, tragacanth, sodium alginate, carboxymethylcellulose, polyethylene glycol, waxes, and the like; and, optionally, lubricating agents, for example, without limitation, magnesium stearate, sodium stearate, stearic acid, sodium oleate, sodium benzoate, sodium acetate, sodium chloride, talc, and the like.

25 In powder forms, the carrier may be a finely divided solid which is in admixture with the finely divided active ingredient. The active ingredient may be mixed with a carrier having binding properties in suitable proportions and compacted in the shape and size desired to produce tablets. The powders and tablets preferably contain from
30 about 1 to about 99 weight percent of the active ingredient which is the novel

composition of the present invention. Suitable solid carriers are magnesium carboxymethyl cellulose, low melting waxes, and cocoa butter.

5 Sterile liquid formulations include suspensions, emulsions, syrups and elixirs. The active ingredient can be dissolved or suspended in a pharmaceutically acceptable carriers, such as sterile water, sterile organic solvent, or a mixture of both sterile water and sterile organic solvent.

10 The active ingredient can also be dissolved in a suitable organic solvent, for example, aqueous propylene glycol. Other compositions can be made by dispersing the finely divided active ingredient in aqueous starch or sodium carboxymethyl cellulose solution or in a suitable oil.

15 The formulation may be in unit dosage form, which is a physically discrete unit containing a unit dose, suitable for administration in human or other mammals. A unit dosage form can be a capsule or tablets, or a number of capsules or tablets. A "unit dose" is a predetermined quantity of the active compound of the present invention, calculated to produce the desired therapeutic effect, in association with one or more excipients. The quantity of active ingredient in a unit dose may be
20 varied or adjusted from about 0.1 to about 1000 milligrams or more according to the particular treatment involved.

25 Typical oral dosages of the present invention, when used for the indicated effects, will range from about 0.01mg /kg/day to about 100 mg/kg/day, preferably from 0.1 mg/kg/day to 30 mg/kg/day, and most preferably from about 0.5 mg/kg/day to about 10 mg/kg/day. In the case of parenteral administration, it has generally proven advantageous to administer quantities of about 0.001 to 100 mg/kg/day, preferably from 0.01 mg/kg/day to 1 mg/kg/day. The compounds of the present invention may be administered in a single daily dose, or the total daily dose may be administered in
30 divided doses, two, three, or more times per day. Where delivery is via transdermal forms, of course, administration is continuous.

EXAMPLES

The present invention will be described as a form of examples, but they should by no means be construed as defining the metes and bounds of the present invention.

5

In the examples below, all quantitative data, if not stated otherwise, relate to percentages by weight.

Mass spectra were obtained using electrospray (ES) ionization techniques (micromass Platform LC). Melting points are uncorrected. Liquid Chromatography - Mass spectroscopy (LC-MS) data were recorded on a Micromass Platform LC with Shimadzu Phenomenex ODS column(4.6 mm ϕ X 30 mm) flushing a mixture of acetonitrile-water (9:1 to 1:9) at 1 ml/min of the flow rate. TLC was performed on a precoated silica gel plate (Merck silica gel 60 F-254). Silica gel (WAKO-gel C-200 (75-150 μ m)) was used for all column chromatography separations. All chemicals were reagent grade and were purchased from Sigma-Aldrich, Wako pure chemical industries, Ltd., Great Britain, Tokyo kasei kogyo Co., Ltd., Nacalai tesque, Inc., Watanabe Chemical Ind. Ltd., Maybridge plc, Lancaster Synthesis Ltd., Merck KgaA, Germany, Kanto Chemical Co., Ltd.

20

^1H NMR spectra were recorded using either Bruker DRX-300 (300 MHz for ^1H) spectrometer or Bruker 500 UltraShieldTM (500 MHz for ^1H). Chemical shifts are reported in parts per million (ppm) with tetramethylsilane (TMS) as an internal standard at zero ppm. Coupling constant (J) are given in hertz and the abbreviations s, d, t, q, m, and br refer to singlet, doublet, triplet, quartet, multiplet, and broad, respectively. The mass determinations were carried out by MAT95 (Finnigan MAT).

25

All starting materials are commercially available or can be prepared using methods cited in the literature.

30

The effect of the present compounds were examined by the following assays and pharmacological tests.

5 [Measurement of capsaicin-induced Ca^{2+} influx in the human VR1-transfected CHO cell line] (Assay 1)

(1) Establishment of the human VR1-CHOluc9aeq cell line

10 Human vanilloid receptor (hVR1) cDNA was cloned from libraries of axotomized dorsal root ganglia (WO 00/29577). The cloned hVR1 cDNA was constructed with pcDNA3 vector and transfected into a CHOluc9aeq cell line. The cell line contains aequorin and CRE-luciferase reporter genes as read-out signals. The transfectants were cloned by limiting dilution in selection medium (DMEM/F12 medium (Gibco BRL) supplemented with 10% FCS,
15 1.4 mM Sodium pyruvate, 20 mM HEPES, 0.15% Sodium bicarbonate, 100 U/ml penicillin, 100 $\mu\text{g}/\text{ml}$ streptomycin, 2 mM glutamine, non-essential amino acids and 2 mg/ml G418). Ca^{2+} influx was examined in the capsaicin-stimulated clones. A high responder clone was selected and used for further experiments in the project. The human VR1-CHOluc9aeq cells were
20 maintained in the selection medium and passaged every 3-4 days at $1\text{--}2.5 \times 10^5$ cells/flask (75 mm^2).

(2) Measurement of Ca^{2+} influx using FDSS-3000

25 Human VR1-CHOluc9aeq cells were suspended in a culture medium which is the same as the selection medium except for G418 and seeded at a density of 1,000 cells per well into 384-well plates (black walled clear-base / Nalge Nunc International). Following the culture for 48 hrs the medium was changed to 2 μM Fluo-3 AM (Molecular Probes) and 0.02% Puroic F-127 in
30 assay buffer (Hank's balanced salt solution (HBSS), 17 mM HEPES (pH7.4), 1 mM Probenecid, 0.1% BSA) and the cells were incubated for 60 min at 25°C. After washing twice with assay buffer the cells were incubated with a

test compound or vehicle for 20 min at 25°C. Mobilization of cytoplasmic Ca^{2+} was measured by FDSS-3000 ($\lambda_{\text{ex}}=488\text{nm}$, $\lambda_{\text{em}}=540\text{nm}$ / Hamamatsu Photonics) for 60 sec after the stimulation with 10 nM capsaicin. Integral R was calculated and compared with controls.

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[Measurement of the capsaicin-induced Ca^{2+} influx in primary cultured rat dorsal root ganglia neurons] (Assay 2)

(1) Preparation of rat dorsal root ganglia neurons

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New born Wister rats (5-11 days) were sacrificed and dorsal root ganglia (DRG) was removed. DRG was incubated with 0.1% trypsin (Gibco BRL) in PBS(-) (Gibco BRL) for 30 min at 37°C, then a half volume of fetal calf serum (FCS) was added and the cells were spun down. The DRG neuron cells were resuspended in Ham F12/5% FCS/5% horse serum (Gibco BRL) and dispersed by repeated pipetting and passing through 70 μm mesh (Falcon). The culture plate was incubated for 3 hours at 37°C to remove contaminating Schwann cells. Non-adherent cells were recovered and further cultured in laminin-coated 384 well plates (Nunc) at 1×10^4 cells/50 μl /well for 2 days in the presence of 50 ng/ml recombinant rat NGF (Sigma) and 50 μM 5-fluorodeoxyuridine (Sigma).

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(2) Ca^{2+} mobilization assay

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DRG neuron cells were washed twice with HBSS supplemented with 17 mM HEPES (pH 7.4) and 0.1% BSA. After incubating with 2 μM fluo-3AM (Molecular Probe), 0.02% PF127 (Gibco BRL) and 1 mM probenecid (Sigma) for 40 min at 37°C, cells were washed 3 times. The cells were incubated with VR1 antagonists or vehicle (dimethylsulphoxide) and then with 1 μM capsaicin in FDSS-6000 ($\lambda_{\text{ex}}=480\text{nm}$, $\lambda_{\text{em}}=520\text{nm}$ / Hamamatsu Photonics). The fluorescence changes at 480nm were monitored for 2.5 min. Integral R was calculated and compared with controls.

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[Organ bath assay to measure the capsaicin-induced bladder contraction] (Assay 3)

Male Wistar rats (10 week old) were anesthetized with ether and sacrificed by
5 dislocating the necks. The whole urinary bladder was excised and placed in
oxygenated Modified Krebs-Henseleit solution (pH 7.4) of the following
composition (112 mM NaCl, 5.9 mM KCl, 1.2 mM MgCl₂, 1.2mM NaH₂PO₄, 2 mM
CaCl₂, 2.5 mM NaHCO₃, 12 mM glucose). Contractile responses of the urinary
bladder were studied as described previously [Maggi CA et al: Br.J.Pharmacol. 108:
10 801-805, 1993]. Isometric tension was recorded under a load of 1 g using
longitudinal strips of rat detrusor muscle. Bladder strips were equilibrated for 60 min
before each stimulation. Contractile response to 80 mM KCl was determined at
15 min intervals until reproducible responses were obtained. The response to KCl
was used as an internal standard to evaluate the maximal response to capsaicin. The
15 effects of the compounds were investigated by incubating the strips with compounds
for 30 min prior to the stimulation with 1 μ M capsaicin (vehicle: 80% saline, 10%
EtOH, and 10% Tween 80). One of the preparations made from the same animal was
served as a control while the others were used for evaluating compounds. Ratio of
each capsaicin-induced contraction to the internal standard (i.e. KCl-induced contrac-
20 tion) was calculated and the effects of the test compounds on the capsaicin-induced
contraction were evaluated.

[Measurement of Ca²⁺ influx in the human P2X1-transfected CHO cell line]

25 (1) Preparation of the human P2X1-transfected CHO_{luc9aeq} cell line

Human P2X1-transfected CHO_{luc9aeq} cell line was established and main-
tained in Dulbecco's modified Eagle's medium (DMEM/F12) supplemented
with 7.5% FCS, 20 mM HEPES-KOH (pH 7.4), 1.4 mM sodium pyruvate,
30 100 U/ml penicillin, 100 μ g/ml streptomycin, 2 mM glutamine (Gibco BRL)
and 0.5 Units/ml apyrase (grade I, Sigma). The suspended cells were seeded
in each well of 384-well optical bottom black plates (Nalge Nunc Inter-

national) at 3×10^3 / 50 μ l / well. The cells were cultured for following 48 hrs to adhere to the plates.

(2) Measurement of the intracellular Ca^{2+} levels

5 P2X1 receptor agonist-mediated increases in cytosolic Ca^{2+} levels were measured using a fluorescent Ca^{2+} chelating dye, Fluo-3 AM (Molecular Probes). The plate-attached cells were washed twice with washing buffer (HBSS, 17 mM HEPES-KOH (pH 7.4), 0.1% BSA and 0.5 units/ml apyrase),
10 and incubated in 40 μ l of loading buffer (1 μ M Fluo-3 AM, 1 mM probenecid, 1 μ M cyclosporin A, 0.01% pluronic (Molecular Probes) in washing buffer) for 1 hour in a dark place. The plates were washed twice with 40 μ l washing buffer and 35 μ l of washing buffer were added in each well with 5 μ l of test compounds or 2',3'-*o*-(2,4,6-trinitrophenyl) adenosine 5'-triphosphate (Molecular Probes) as a reference. After further incubation for
15 10 minutes in dark 200 nM α , β -methylene ATP agonist was added to initiate the Ca^{2+} mobilization. Fluorescence intensity was measured by FDSS-6000 (λ_{ex} =410nm, λ_{em} =510nm / Hamamatsu Photonics) at 250 msec intervals. Integral ratios were calculated from the data and compared with that of a
20 control.

[Measurement of capsaicin-induced bladder contraction in anesthetized rats]
(Assay 4)

25 (1) Animals

Female Sprague-Dawley rats (200~250 g / Charles River Japan) were used.

(2) Catheter implantation

30 Rats were anesthetized by intraperitoneal administration of urethane (Sigma) at 1.2 g/kg. The abdomen was opened through a midline incision, and a

polyethylene catheter (BECTON DICKINSON, PE50) was implanted into the bladder through the dome. In parallel, the inguinal region was incised, and a polyethylene catheter (Hibiki, size 5) filled with 2 IU / ml of heparin (Novo Heparin, Aventis Pharma) in saline (Otsuka) was inserted into a common iliac artery.

(3) Cystometric investigation

The bladder catheter was connected via T-tube to a pressure transducer (Viggo-Spectramed Pte Ltd, DT-XXAD) and a microinjection pump (TERUMO). Saline was infused at room temperature into the bladder at a rate of 2.4 ml/hr. Intravesical pressure was recorded continuously on a chart pen recorder (Yokogawa). At least three reproducible micturition cycles, corresponding to a 20-minute period, were recorded before a test compound administration and used as baseline values.

(4) Administration of test compounds and stimulation of bladder with capsaicin

The saline infusion was stopped before administrating compounds. A testing compound dissolved in the mixture of ethanol, Tween 80 (ICN Biomedicals Inc.) and saline (1 : 1 : 8, v/v/v) was administered intraarterially at 10 mg/kg. 2min after the administration of the compound 10 µg of capsaicin (Nacalai Tesque) dissolved in ethanol was administered intraarterially.

(5) Analysis of cystometry parameters

Relative increases in the capsaicin-induced intravesical pressure were analyzed from the cystometry data. The capsaicin-induced bladder pressures were compared with the maximum bladder pressure during micturition without the capsaicin stimulation. The testing compounds-mediated inhibition of the increased bladder pressures was evaluated using Student's t-test. A probability level less than 5% was accepted as significant difference.

[Measurement of over active bladder in anesthetized cystitis rats] (Assay 5)

(1) Animals

Female Sprague-Dawley rats (180~250 g / Charles River Japan) were used. Cyclophosphamide (CYP) dissolved in saline was administered intraperitoneally at 150 mg/kg 48 hours before experiment.

(2) Catheter implantation

Rats were anesthetized by intraperitoneal administration of urethane (Sigma) at 1.25 g/kg. The abdomen was opened through a midline incision, and a polyethylene catheter (BECTON DICKINSON, PE50) was implanted into the bladder through the dome. In parallel, the inguinal region was incised, and a polyethylene catheter (BECTON DICKINSON, PE50) filled with saline (Otsuka) was inserted into a femoral vein. After the bladder was emptied, the rats were left for 1 hour for recovery from the operation.

(3) Cystometric investigation

The bladder catheter was connected via T-tube to a pressure transducer (Viggo-Spectramed Pte Ltd, DT-XXAD) and a microinjection pump (TERUMO). Saline was infused at room temperature into the bladder at a rate

of 3.6 ml/hr for 20 min. Intravesical pressure was recorded continuously on a chart pen recorder (Yokogawa). At least three reproducible micturition cycles, corresponding to a 20-minute period, were recorded before a test compound administration.

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(4) Administration of test compounds

A testing compound dissolved in the mixture of ethanol, Tween 80 (ICN Biomedicals Inc.) and saline (1 : 1 : 8, v/v/v) was administered intravenously at 0.05 mg/kg, 0.5 mg/kg or 5 mg/kg. 3min after the administration of the compound, saline (Nacalai Tesque) was infused at room temperature into the bladder at a rate of 3.6 ml/hr.

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(5) Analysis of cystometry parameters

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The cystometry parameters were analyzed as described previously [Lecci A et al: Eur. J. Pharmacol. 259: 129-135, 1994]. The micturition frequency calculated from micturition interval and the bladder capacity calculated from a volume of infused saline until the first micturition were analyzed from the cystometry data. The testing compounds-mediated inhibition of the frequency and the testing compounds-mediated increase of bladder capacity were evaluated using unpaired Student's t-test. A probability levels less than 5% was accepted as significant difference. Data were analyzed as the mean \pm SEM from 4 – 7 rats.

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[Measurement of Acute Pain]

Acute pain is measured on a hot plate mainly in rats. Two variants of hot plate testing are used: In the classical variant animals are put on a hot surface (52 to 56°C) and the latency time is measured until the animals show nocifensive behavior, such as stepping or foot licking. The other variant is an increasing temperature hot plate where the experimental animals are put on a surface of neutral temperature. Subsequently this surface is slowly but constantly heated until the animals begin to

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lick a hind paw. The temperature which is reached when hind paw licking begins is a measure for pain threshold.

5 Compounds are tested against a vehicle treated control group. Substance application is performed at different time points via different application routes (i.v., i.p., p.o., i.t., i.c.v., s.c., intradermal, transdermal) prior to pain testing.

[Measurement of Persistent Pain]

10 Persistent pain is measured with the formalin or capsaicin test, mainly in rats. A solution of 1 to 5% formalin or 10 to 100 µg capsaicin is injected into one hind paw of the experimental animal. After formalin or capsaicin application the animals show nocifensive reactions like flinching, licking and biting of the affected paw. The number of nocifensive reactions within a time frame of up to 90 minutes is a measure for intensity of pain.

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Compounds are tested against a vehicle treated control group. Substance application is performed at different time points via different application routes (i.v., i.p., p.o., i.t., i.c.v., s.c., intradermal, transdermal) prior to formalin or capsaicin administration.

20 [Measurement of Neuropathic Pain]

Neuropathic pain is induced by different variants of unilateral sciatic nerve injury mainly in rats. The operation is performed under anesthesia. The first variant of sciatic nerve injury is produced by placing loosely constrictive ligatures around the common sciatic nerve (Bennett and Xie, Pain 33 (1988): 87-107). The second variant is the tight ligation of about the half of the diameter of the common sciatic nerve (Seltzer et al., Pain 43 (1990): 205-218). In the next variant, a group of models is used in which tight ligations or transections are made of either the L5 and L6 spinal nerves, or the L5 spinal nerve only (KIM SH; CHUNG JM, AN EXPERIMENTAL-MODEL FOR PERIPHERAL NEUROPATHY PRODUCED BY SEGMENTAL SPINAL NERVE LIGATION IN THE RA, PAIN 50 (3) (1992): 355-363). The fourth variant involves an axotomy of two of the three terminal branches of the

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sciatic nerve (tibial and common peroneal nerves) leaving the remaining sural nerve intact whereas the last variant comprises the axotomy of only the tibial branch leaving the sural and common nerves uninjured. Control animals are treated with a sham operation.

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Postoperatively, the nerve injured animals develop a chronic mechanical allodynia, cold allodynia, as well as a thermal hyperalgesia. Mechanical allodynia is measured by means of a pressure transducer (electronic von Frey Anesthesiometer, IITC Inc.-Life Science Instruments, Woodland Hills, SA, USA; Electronic von Frey System, Somedic Sales AB, Hörby, Sweden). Thermal hyperalgesia is measured by means of a radiant heat source (Plantar Test, Ugo Basile, Comerio, Italy), or by means of a cold plate of 5 to 10°C where the nocifensive reactions of the affected hind paw are counted as a measure of pain intensity. A further test for cold induced pain is the counting of nocifensive reactions, or duration of nocifensive responses after plantar administration of acetone to the affected hind limb. Chronic pain in general is assessed by registering the circadian rhythms in activity (Surjo and Arndt, Universität zu Köln, Cologne, Germany), and by scoring differences in gait (foot print patterns; FOOTPRINTS program, Klapdor et al., 1997. A low cost method to analyse footprint patterns. J. Neurosci. Methods 75, 49-54).

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Compounds are tested against sham operated and vehicle treated control groups. Substance application is performed at different time points via different application routes (i.v., i.p., p.o., i.t., i.c.v., s.c., intradermal, transdermal) prior to pain testing.

25 [Measurement of Inflammatory Pain]

Inflammatory pain is induced mainly in rats by injection of 0.75 mg carrageenan or complete Freund's adjuvant into one hind paw. The animals develop an edema with mechanical allodynia as well as thermal hyperalgesia. Mechanical allodynia is measured by means of a pressure transducer (electronic von Frey Anesthesiometer, IITC Inc.-Life Science Instruments, Woodland Hills, SA, USA). Thermal hyperalgesia is measured by means of a radiant heat source (Plantar Test, Ugo Basile,

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Comerio, Italy, Paw thermal stimulator, G. Ozaki, University of California, USA).
For edema measurement two methods are being used. In the first method, the animals
are sacrificed and the affected hindpaws sectioned and weighed. The second method
comprises differences in paw volume by measuring water displacement in a
5 plethysmometer (Ugo Basile, Comerio, Italy).

Compounds are tested against uninflamed as well as vehicle treated control groups.
Substance application is performed at different time points via different application
routes (i.v., i.p., p.o., i.t., i.c.v., s.c., intradermal, transdermal) prior to pain testing.

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[Measurement of Diabetic Neuropathic Pain]

Rats treated with a single intraperitoneal injection of 50 to 80 mg/kg streptozotocin
develop a profound hyperglycemia and mechanical allodynia within 1 to 3 weeks.
Mechanical allodynia is measured by means of a pressure transducer (electronic von
15 Frey Anesthesiometer, IITC Inc.-Life Science Instruments, Woodland Hills, SA,
USA).

Compounds are tested against diabetic and non-diabetic vehicle treated control
groups. Substance application is performed at different time points via different
20 application routes (i.v., i.p., p.o., i.t., i.c.v., s.c., intradermal, transdermal) prior to
pain testing.

Results of IC₅₀ of capsaicin-induced Ca²⁺ influx in the human VR1-transfected CHO
cell line are shown in Examples and tables of the Examples below. The data
25 corresponds to the compounds as yielded by solid phase synthesis and thus to levels
of purity of about 40 to 90%. For practical reasons, the compounds are grouped in
four classes of activity as follows:

$$IC_{50} = A (< \text{ or } =) 0.1 \mu\text{M} < B (< \text{ or } =) 0.5 \mu\text{M} < C (< \text{ or } =) 1 \mu\text{M} < D$$

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The compounds of the present invention also show excellent selectivity, and strong
activity in other assays 2-5 described above.

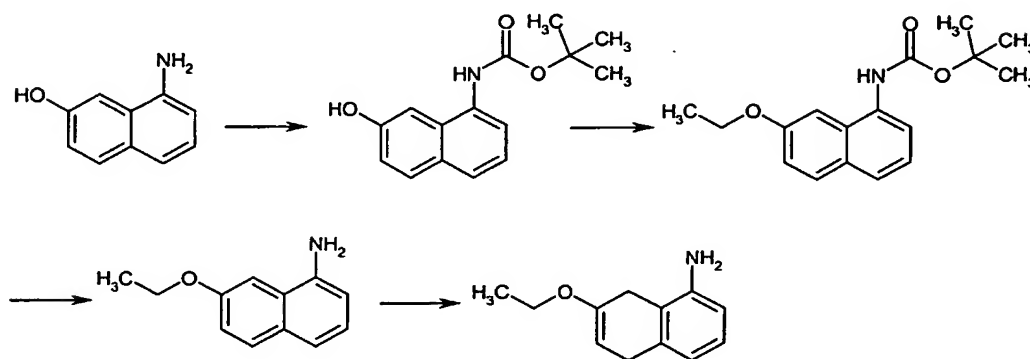
Z used in melting point in the following section indicates decomposition.

Preparation of compounds

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[Starting compound A]

(7-Ethoxy-5,8-dihydronaphthalen-1-yl)amine



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To a stirred solution of 8-amino-2-naphthol (50.0 g, 314 mmol) in tetrahydrofuran (1000 mL) was added di-*t*-butyldicarbonate (68.6 g, 314 mmol). The mixture was stirred at 70°C for 18 hours. After the mixture was cooled to room temperature, solvent was removed under reduced pressure. To the residue was added ethylacetate, and washed with saturated aqueous solution of sodium carbonate and then with water. The extracted organic layer was dried over Na₂SO₄, filtered, and concentrated under reduced pressure. To the obtained residue was added diisopropyl ether, and the precipitate was filtered and dried to afford tert-butyl(7-hydroxy-1-naphthyl)carbamate (64.2 g, 79 % yield).

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Next, to a mixture of tert-butyl (7-hydroxy-1-naphthyl)carbamate (64.0 g, 247 mmol) and cesium carbonate (161 g, 493 mmol) in 300 mL anhydrous DMF was added iodoethane (42.3 g, 272 mmol) at room temperature. The mixture was stirred at 60°C for 2 hours. Water was added to the mixture, and the product was extracted with

ethylacetate. The organic layer was washed with water and brine, dried over Na_2SO_4 , filtered, and concentrated under reduced pressure. To the obtained residue was added diisopropyl ether and the precipitate was collected and dried to afford tert-butyl (7-ethoxy-1-naphthyl)carbamate (47.9 g, 67.5 % yield).

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Next, to a solution of tert-butyl (7-ethoxy-1-naphthyl)carbamate (47.9 g, 167 mmol) in 100 mL anhydrous 1,4-dioxane was added 4N HCl in 1,4-dioxane (100 mL) at 0°C . The mixture was stirred at room temperature for 2 hours. Diisopropyl ether was added to the reaction mixture and the precipitate was filtered. To the obtained solid was added saturated sodium bicarbonate and the product was extracted with ethylacetate. The organic layer was dried over Na_2SO_4 , filtered, and concentrated under reduced pressure to afford (7-ethoxy-1-naphthyl)amine (27.0 g, 86.3 % yield).

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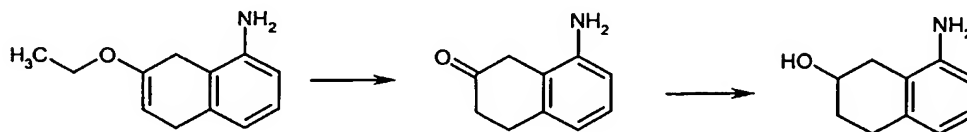
Next, to a flask containing a mixture of (7-ethoxy-1-naphthyl)amine (1.80 g, 9.61 mmol) and t-butanol (2.13 g, 28.8 mmol) in tetrahydrofuran (20 mL) was collected liquid ammonia (300 mL) at -78°C . To the mixture was added lithium (0.200 g, 28.8 mmol) over 30 minutes and stirred at -78°C for 1 hour. Methanol and water was added, and the mixture was stirred at room temperature for 16 hours to allow ammonia to evaporate. To the obtained residue was added ethylacetate. The organic layer was washed with water, dried over Na_2SO_4 , filtered, and concentrated under reduced pressure to afford (7-ethoxy-5,8-dihydronaphthalen-1-yl)amine (1.37 g, 76 % yield).

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[Starting compound B]

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8-Amino-1,2,3,4-tetrahydro-naphthalen-2-ol



To a stirred solution of (7-ethoxy-5,8-dihydronaphthalen-1-yl)amine (1.07 g, 5.65 mmol) in tetrahydrofuran (30 mL) was added solution of aqueous 2N HCl (10 mL), and stirred at 40°C for 1 hour. The mixture was neutralized with addition of sodium bicarbonate, and the product was extracted with ethylacetate. The organic layer was washed with water, dried over Na₂SO₄, filtered, and concentrated under reduced pressure to afford 8-amino-3,4-dihydronaphthalen-2(1H)-one (0.71 g, 78 % yield).

Next, to 8-amino-3,4-dihydronaphthalen-2(1H)-one (0.050 g, 0.318 mmol) in methanol (10 mL) was added sodium borohydride (0.030 g, 0.175 mmol) at 0°C, and the mixture was stirred for 1 hour. The mixture was poured into water, and the product was extracted with ethylacetate. The organic layer was dried over Na₂SO₄, filtered, and concentrated under reduced pressure to afford 8-amino-1,2,3,4-tetrahydronaphthalen-2-ol (0.037 g, 71 % yield).

[Starting compound C]

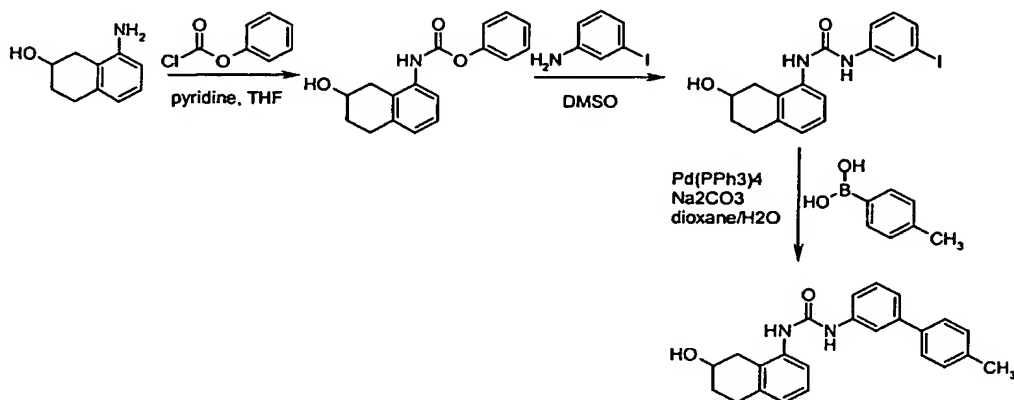
8-Amino-1,2,3,4-tetrahydro-naphthalen-2-ol chiral enantiomer



To a stirred solution of benzenoruthenium(II) chloride dimer (3.10 mg, 0.006 mmol) and (1S, 2R)-(-)-cis-1-amino-2-indanol (3.7 mg, 0.025 mmol) in degaussed isopropanol was heated at 80°C for 20 minutes under argon. The mixture was added to the solution of 8-amino-3,4-dihydronaphthalen-2(1H)-one (50 mg, 0.310 mmol) in isopropanol (3 mL) at room temperature. A solution of potassium hydroxide (3.48 mg, 0.062 mmol) in isopropanol (1 mL) was added, and the mixture was stirred at 45°C for 1 hour. The mixture was passed through silica gel and washed with ethylacetate. The filtrate was concentrated under reduced pressure to afford the 8-amino-1,2,3,4-tetrahydro-naphthalen-2-ol chiral enantiomer (33.0 mg, 65 % yield).

Example 1-1**N-(7-Hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)-N'-(4'-methylbiphenyl-3-yl)urea**

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To a stirred solution of 8-amino-1,2,3,4-tetrahydro-naphthalen-2-ol (30.0 mg, 0.18 mmol) and pyridine (21.8 mg, 0.28 mmol) in 1.0 mL THF was added phenyl chloroformate (30.2 mg, 0.19 mmol), and the mixture was stirred for 1 hour at room temperature. To the product mixture was added water and extracted with ethylacetate. The organic layer was washed with brine, dried over Na₂SO₄, filtered and concentrated under reduced pressure. The obtained residue was triturated with ethylacetate and hexane to afford phenyl (7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)carbamate (25.2 mg, 48 % yield).

Next, a mixture of phenyl (7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)carbamate (30.0 mg, 0.11 mmol) and 3-iodoaniline (25.5 mg, 0.12 mmol) in 0.2 mL of DMSO was heated at 100°C for 16 hours. After cooled to room temperature, water was added and the product was extracted with ethylacetate. The organic layer was washed with water then brine, dried over Na₂SO₄, filtered, and concentrated under reduced pressure to obtain N-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)-N'-(3-iodophenyl)urea (20.3 mg, 47 % yield).

Next, to a solution of N-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)-N'-(3-iodophenyl)urea (9.0 mg, 0.02 mmol) and 4-tolylboronic acid (3.60 mg, 0.03 mmol) in THF was added tetrakis(triphenylphosphine)palladium(0) (2.55 mg) followed by 0.1 mL of saturated sodium bicarbonate solution. The mixture was stirred for 3 hours at 90°C, then ethylacetate was added. The mixture was passed through a short pad of silica gel and was concentrated under reduced pressure to afford N-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)-N'-(4'-methylbiphenyl-3-yl)urea (2.80 mg, 34 % yield).

mp 217-219°C;

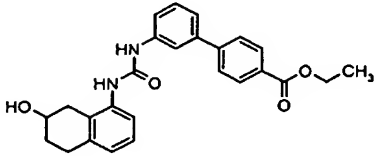
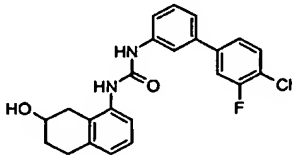
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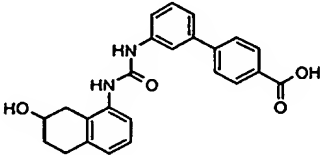

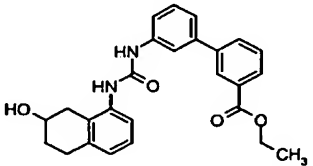
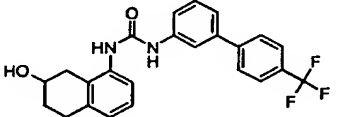
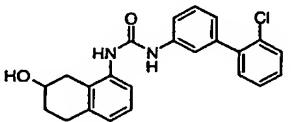
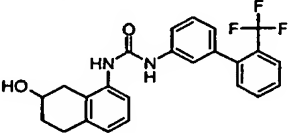
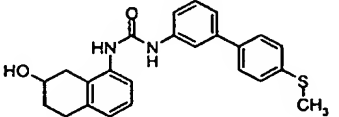
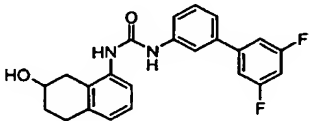
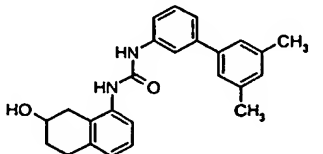
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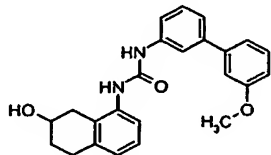
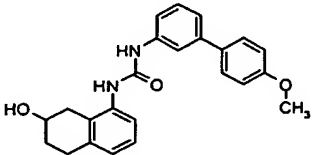
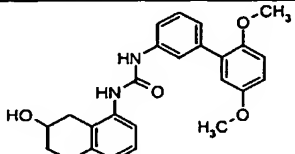
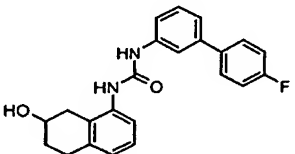
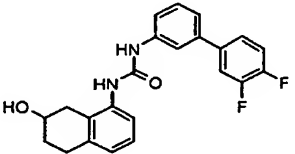
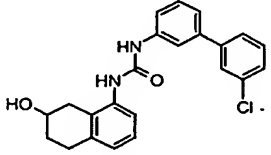
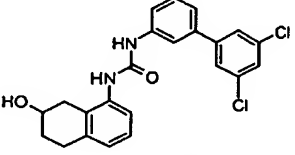
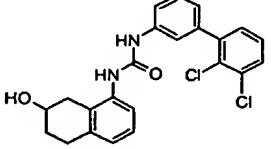
Activity Class : A

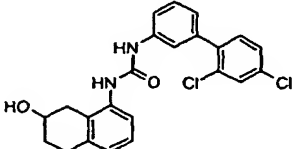
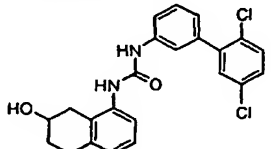
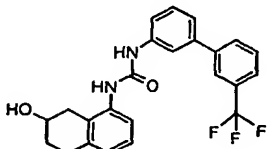
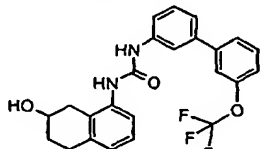
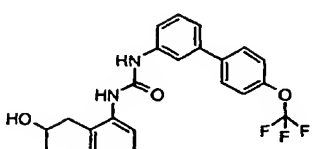
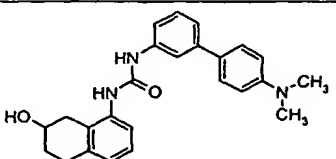
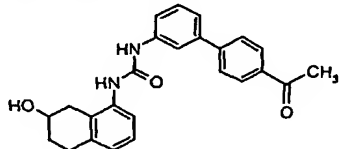
In the similar manner as described in Example 1-1, compounds in Example 1-2 to 1-76 as shown in Table 1 were synthesized.

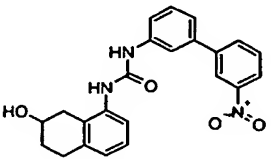
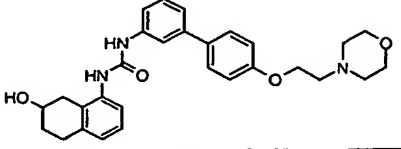
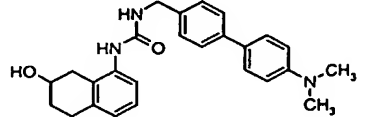
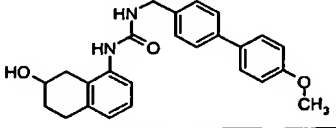
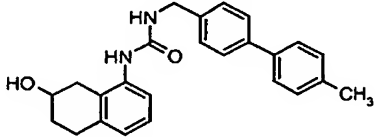
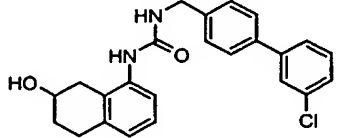
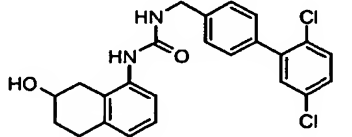
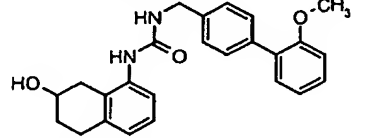
Table 1

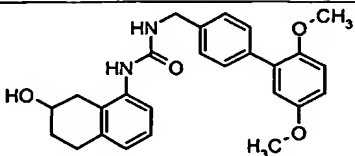
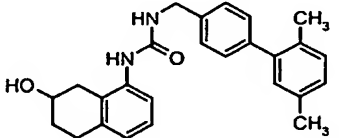
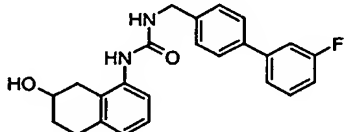
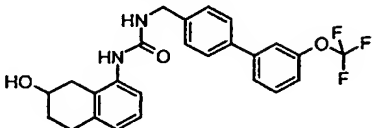
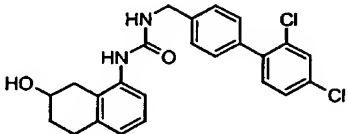
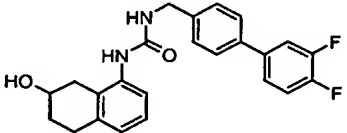
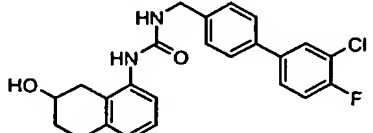
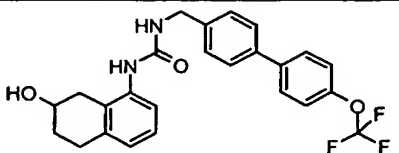
Ex-No.	Structure	MW	MS (M+H)	mp (°C)	Activity Class
1-2		430.51	431	198-200	A
1-3		410.88	411	94-96	A

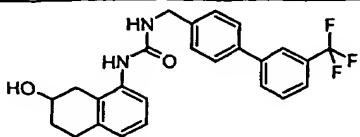
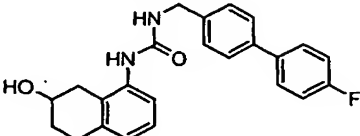
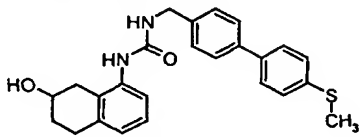
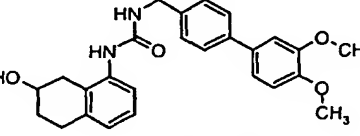
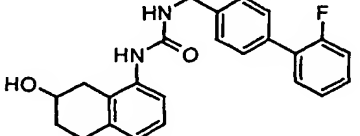
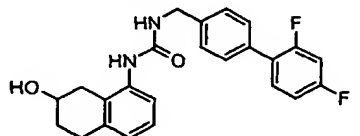
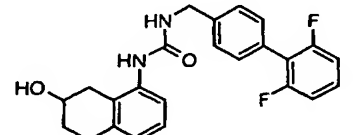
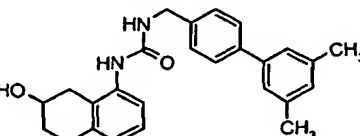
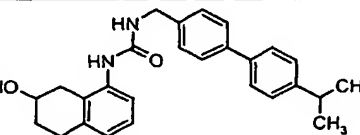
Ex-No.	Structure	MW	MS (M+H)	mp (°C)	Activity Class
1-4		402.45	403	281-284	A
1-5		394.42	395	187-189	A
1-6		430.51	431	142-144	A
1-7		426.44	427	amorphous	A
1-8		392.89	393	amorphous	A
1-9		426.44	427	amorphous	A
1-10		404.54	405	amorphous	A
1-11		394.42	395	amorphous	A
1-12		386.5	387	221	A

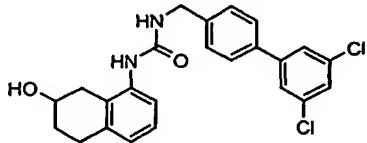
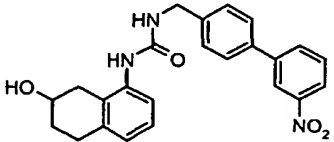
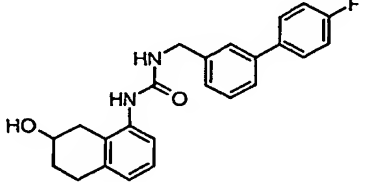
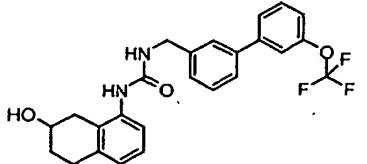
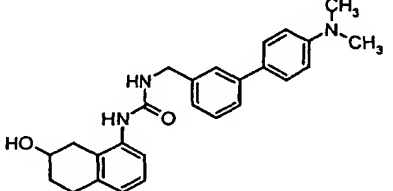
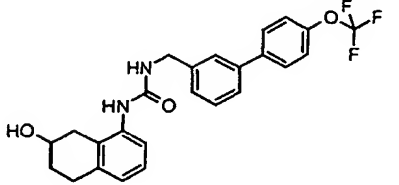
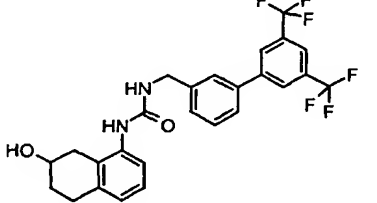
Ex-No.	Structure	MW	MS (M+H)	mp (°C)	Activity Class
1-13		388.47	389	204	A
1-14		388.47	389	203	A
1-15		418.5	419	190	A
1-16		376.43	377	228	A
1-17		394.42	395	216	A
1-18		392.89	393	209	A
1-19		427.33	428	221	A
1-20		427.33	428	204	A

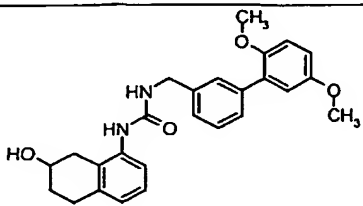
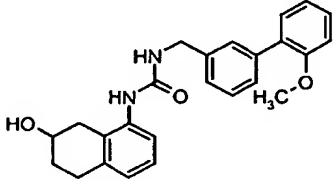
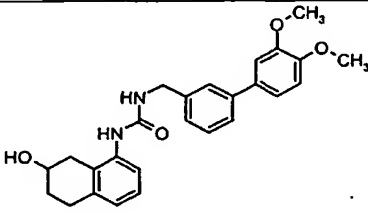
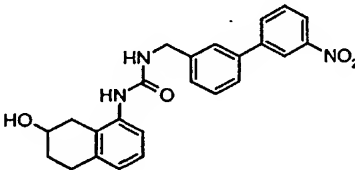
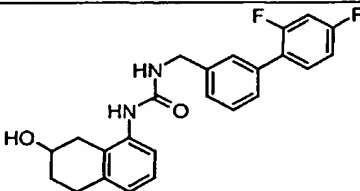
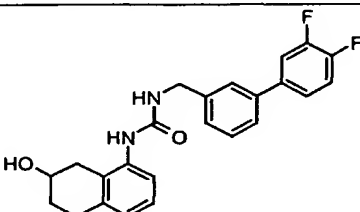
Ex-No.	Structure	MW	MS (M+H)	mp (°C)	Activity Class
1-21		427.33	428	208	A
1-22		427.33	428	209	A
1-23		426.44	427	210	A
1-24		442.44	443	195	A
1-25		442.44	443	210	A
1-26		401.51	402	215	A
1-27		400.48	401	216	A

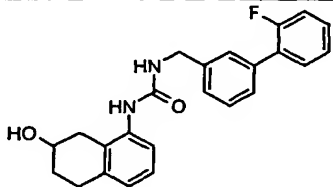
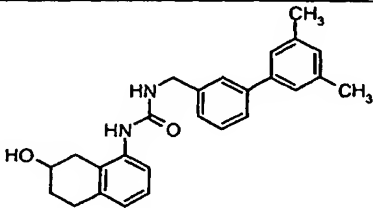
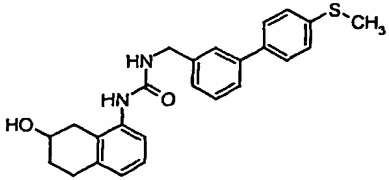
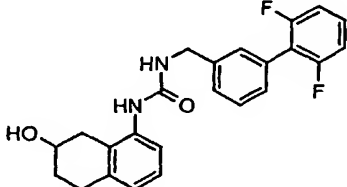
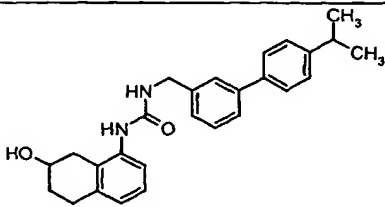
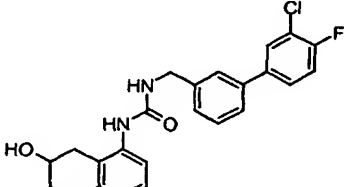
Ex-No.	Structure	MW	MS (M+H)	mp (°C)	Activity Class
1-28		403.44	404	238	A
1-29		487.6	488	>127Z	A
1-30		415.54	416	205-206	A
1-31		402.5	403	215-216	A
1-32		386.5	387	211-212	A
1-33		406.92	407	195-196	A
1-34		441.36	442	139-140	A
1-35		402.5	403	128-129	A

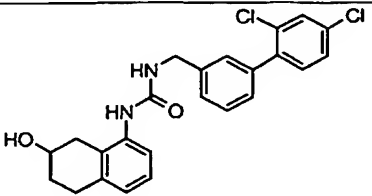
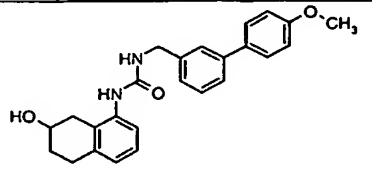
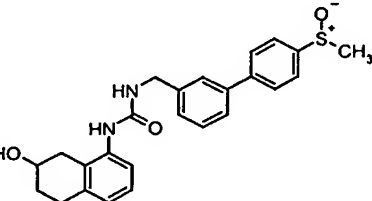
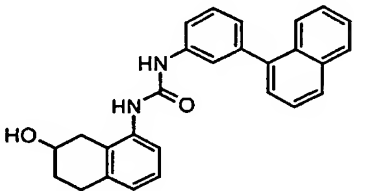
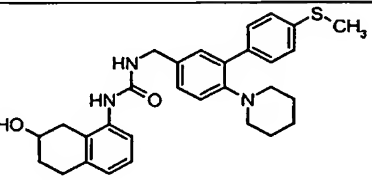
Ex-No.	Structure	MW	MS (M+H)	mp (°C)	Activity Class
1-36		432.52	433	113-114	A
1-37		400.53	401	181-182	A
1-38		390.46	391	191-192	A
1-39		456.47	457	218-219	A
1-40		441.36	442	177-178	A
1-41		408.45	409	191-192	A
1-42		424.91	425	205-206	A
1-43		456.47	457	199-200	A

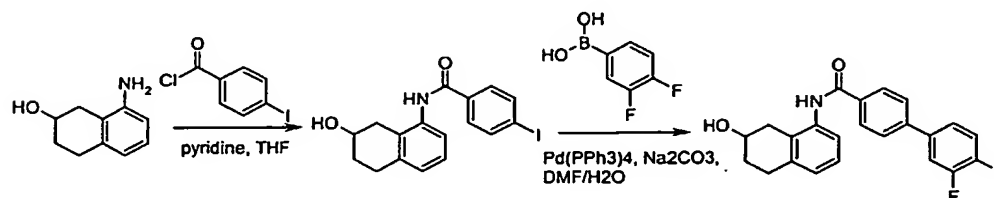
Ex-No.	Structure	MW	MS (M+H)	mp (°C)	Activity Class
1-44		440.47	441	196-197	A
1-45		390.46	391	201-202	A
1-46		418.56	419	216-217	A
1-47		432.52	433	205-206	C
1-48		390.46	391	187-188	A
1-49		408.45	409	191-192	A
1-50		408.45	409	204-205	A
1-51		400.53	401	205-206	A
1-52		414.55	415	202-203	A

Ex-No.	Structure	MW	MS (M+H)	mp (°C)	Activity Class
1-53		441.36	442	204-205	A
1-54		417.47	418	206-207	A
1-55		390.46	391	194-195	A
1-56		456.47	457	175-176	A
1-57		415.54	416	207-208	A
1-58		456.47	457	188-189	A
1-59		508.47	509	208-209	A

Ex-No.	Structure	MW	MS (M+H)	mp (°C)	Activity Class
1-60		432.52	433	123-124	A
1-61		402.5	403	129-130	A
1-62		432.52	433	223-224	A
1-63		417.47	418	191-192	A
1-64		408.45	409	197-198	A
1-65		408.45	409	188-189	A

Ex-No.	Structure	MW	MS (M+H)	mp (°C)	Activity Class
1-66		390.46	391	197-198	A
1-67		400.53	401	197-198	A
1-68		418.56	419	195-196	A
1-69		408.45	409	141-142	A
1-70		414.55	415	202-203	A
1-71		424.91	425	188-189	A

Ex-No.	Structure	MW	MS (M+H)	mp (°C)	Activity Class
1-72		441.36	442	152-153	A
1-73		402.5	403	188-189	A
1-74		434.56	435	110-112	A
1-75		408.5	409	223	A
1-76		501.7	502	113-115	A

Example 2-1**3',4'-Difluoro-N-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)biphenyl-4-carboxamide**

5

To a stirred solution of 8-amino-1,2,3,4-tetrahydro-naphthalen-2-ol (1.00 g, 6.13 mmol) in 30 mL THF was added pyridine (0.727 g, 9.19 mmol) and then cooled to 0°C. To the mixture was added 4-iodobenzoyl chloride (1.94 g, 7.29 mmol) and was slowly warmed to room temperature. After stirred for 1 hour, the mixture was poured into water, and the product was extracted with ethylacetate. The organic layer was washed with brine, dried over Na₂SO₄, filtered and concentrated under reduced pressure. The product was triturated with ethylacetate and hexane, and the resulting solid was collected to afford N-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)-4-iodobenzamide (2.06 g, 80 % yield).

15

Next, to a solution of N-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)-4-iodobenzamide (100 mg, 0.25 mmol) in a 3 to 1 mixture of DMF and H₂O was added 3,4-difluorophenylboronic acid (80.3 mg, 0.51 mmol), tetrakis(triphenylphosphine)-palladium(0) (8.82 mg, 0.01 mmol), and sodium carbonate (80.9 mg, 0.76 mmol). The mixture was stirred at 80°C for 2.5 hours, and after cooled to room temperature, the product was extracted with diethyl ether. The organic layer was washed with water then brine, dried over Na₂SO₄, filtered, and concentrated under reduced pressure. After triturated with ethylacetate and hexane, the solid was filtered to afford 3',4'-difluoro-N-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)biphenyl-4-carboxamide (51.9 mg, 54 %).

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¹H NMR (DMSO-*d*₆) δ 1.53-1.68 (m, 1H), 1.84-1.94 (m, 1H), 2.80 (dd, *J* = 9.3, 5.2 Hz, 1H), 2.86-2.91 (m, 1H), 2.91-2.97 (m, 1H), 3.29 (s, 1H), 3.83-3.94 (m, 1H), 4.77 (d, *J* = 3.9 Hz, 1H), 7.02 (dd, *J* = 6.2, 2.6 Hz, 1H), 7.14 (d, *J* = 3.4 Hz, 1H), 7.15 (s, 1H), 7.52-7.68 (m, 2H), 7.87 (d, *J* = 8.5 Hz, 2H), 7.92 (dd, *J* = 7.8, 2.2 Hz, 1H), 8.08 (d, *J* = 8.5 Hz, 2H), 9.84 (s, 1H).

mp 210.4-212.7°C;

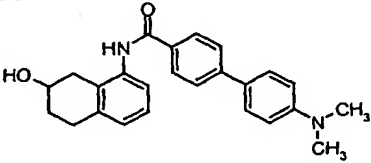
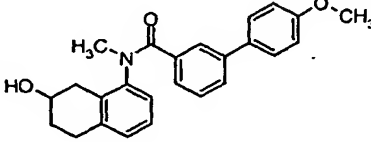
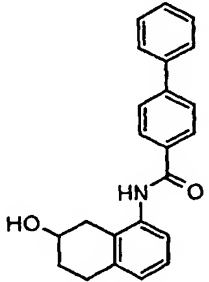
Molecular weight : 379.4

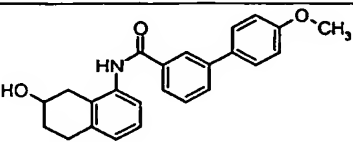
MS (M+H) : 380

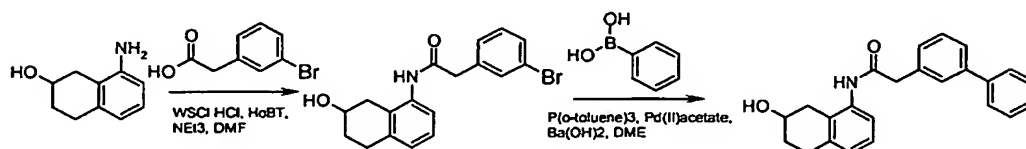
Activity Class : A

In the similar manner as described in Example 2-1, compounds in Example 2-2 to 2-5 as shown in Table 2 were synthesized.

Table 2

Ex-No.	Structure	MW	MS (M+H)	mp (°C)	Activity Class
2-2		386.5	387	222.1-225.0	A
2-3		387.48	388	150.0-151.2	C
2-4		343.43	344	215-217	A

Ex-No.	Structure	MW	MS (M+H)	mp (°C)	Activity Class
2-5		373.46	374	193.3-196.5	C

Example 3 -1**2-Biphenyl-3-yl-N-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)acetamide**

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To a stirred solution of 8-amino-1,2,3,4-tetrahydro-naphthalen-2-ol (500 mg, 3.06 mmol) and 3-bromophenylacetic acid (725 mg, 3.37 mmol) in DMF was added triethylamine (465 mg, 4.60 mmol), 1-hydroxybenzotriazole (497 mg, 3.68 mmol), and 1-ethyl-3-(3-dimethylaminopropyl)-carbodiimide hydrochloride (705 mg, 3.68 mmol). The mixture was stirred for 16 hours at room temperature. To the product mixture was added water and extracted with ethylacetate. The organic layer was washed with aqueous HCl solution then aqueous NaOH solution and brine, dried over MgSO₄, filtered and concentrated under reduced pressure. The product was purified by silica gel column chromatography (hexane:acetone, 2:1) to afford 2-(3-bromophenyl)-N-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)acetamide (130 mg, 12 % yield).

Next, to a mixture of 2-(3-bromophenyl)-N-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)acetamide (50.0 mg, 0.139 mmol), phenyl boronic acid (25.4 mg, 0.208 mmol), tri-*o*-tolylphosphine (8.45 mg, 0.028 mmol), and barium hydroxide octahydrate (65.7 mg, 0.208 mmol) in 12 mL of ethylene glycol dimethyl ether was added ethanol (4 mL), water (4 mL), and palladium(II) acetate (3.12 mg, 0.014 mmol). The mixture was stirred vigorously under argon and was heated to

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reflux. After cooled to room temperature, water was added and the product was extracted with ethylacetate. The organic layer was washed with water then brine, dried over MgSO_4 , filtered, and concentrated under reduced pressure to obtain 2-biphenyl-3-yl-N-(7-hydroxy-5,6,7,8-tetrahydronaphthalen-1-yl)acetamide (13.0 mg, 26 % yield).

^1H NMR ($\text{DMSO}-d_6$) δ 1.60 (m, 1H), 1.84 (m, 1H), 2.72-2.89 (m, 4H), 3.75 (s, 2H), 3.88 (m, 1H), 4.79 (d, $J = 4.1$ Hz, 1H), 6.90 (d, $J = 7.1$ Hz, 1H), 7.04 (t, $J = 7.5$ Hz, 1H), 7.18 (d, $J = 7.7$ Hz, 1H), 7.37-7.56 (m, 7H), 7.66 (d, $J = 7.1$ Hz, 2H), 9.40 (s, 1H).

mp > 134°C decomp.

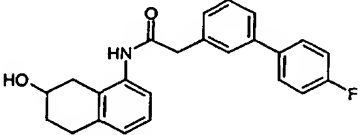
Molecular weight : 357.45

MS (M+H) : 358

Activity Class : C

In the similar manner as described in Example 3-1, compounds in Example 3-2 as shown in Table 3 was synthesized.

Table 3

Ex-No.	Structure	MW	MS (M+H)	mp (°C)	Activity Class
3-2		375.45	376	>103Z	C